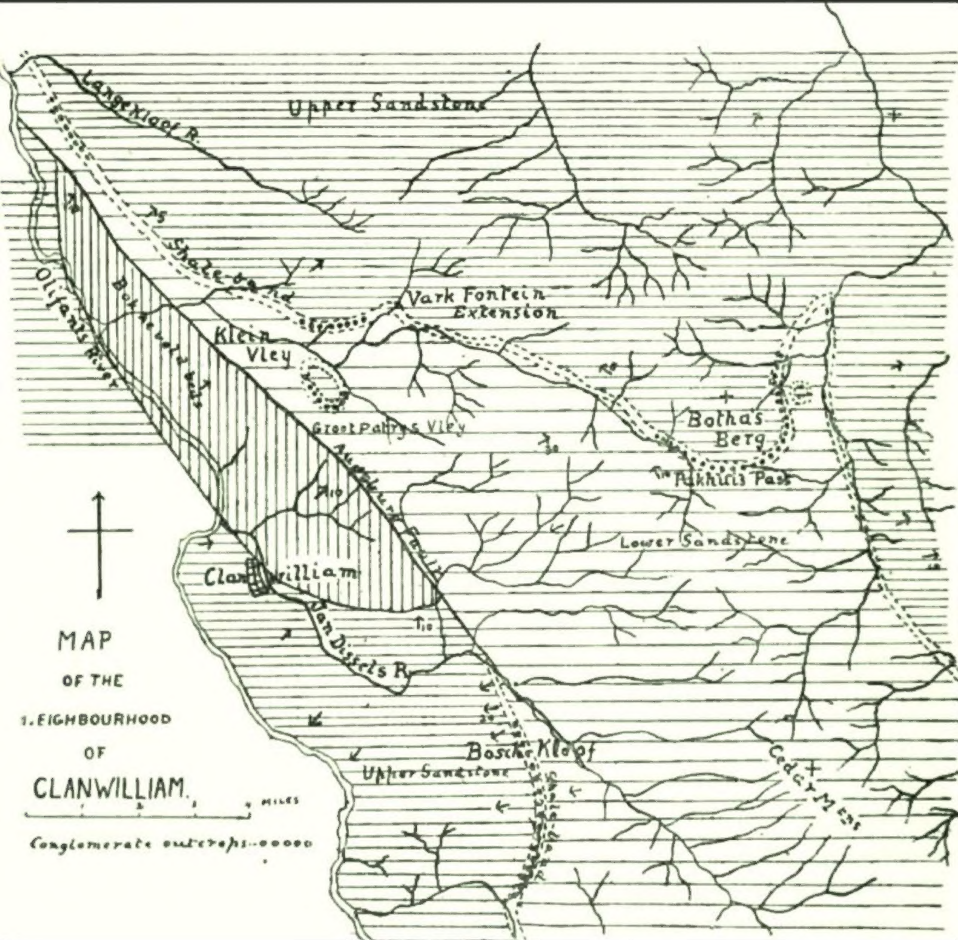
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Clanwilliam
Van Dissels R.
Boschkloof
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Transactions of the South African Philosophical Society

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OF THE

SOUTH AFRICAN PHILOSOPHICAL SOCIETY.

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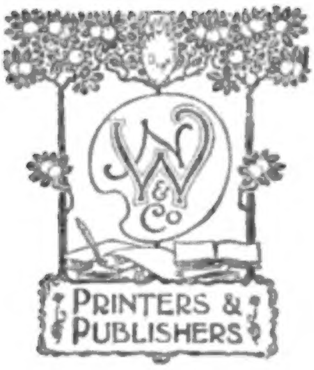
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ADDENDUM.

P. 167. Footnote. This is *M. pubescens*, Haw.

ERRATUM.

P. 385, line 6 from the bottom, for "*Pegolettia dentata*, &c.," read "IPHIONA DENTATA, Bolus, n. sp." (Compositæ-Inuloideæ.)

P. 385, line 5 from the bottom, for "P." read "I."

P. 386, line 18, for "In floral structure nearest to, &c.," read "Nearest to *I. baccharidifolia*, *Benth. & Hook. f.*, distinct by its much narrower and more deeply-toothed leaves, much more numerous, narrower and acuminate involucral scales, and by its silky achenes. It appears to be rare."

P. 407, line 10, for fig. 1 read fig. 2.

P. 407, line 12, for fig. 2 read fig. 1.

P. 411, line 42, for "Iniel" read "Pniel."

PROCEEDINGS

OF THE

SOUTH AFRICAN PHILOSOPHICAL SOCIETY.

Ordinary Monthly Meeting.

September 28, 1904.

Dr. J. D. F. Gilchrist, President, in the Chair.

Rev. E. Goetz, S.J., of Bulawayo, and Mr. E. Oppenheimer, of Kimberley, were nominated as ordinary members by Messrs. J. R. Sutton, and L. Péringuey; Dr. H. Becker, of Grahamstown, by Dr. S. Schönland and L. Péringuey; Mr. F. Weir by Dr. M. Wilson and Dr. E. Landsberg.

Dr. R. Marloth read a Note on a new South African Cypress, *Callitris schwarzii*, Marl.:—

The two species of Cypress hitherto known from South Africa belong to the genus *Widdringtonia*, which, however, is now mostly merged into the genus *Callitris*. Until recently only one other species of *Widdingtonia* was known, viz., *W. Commersoni*, from Madagascar, but lately a fourth species has been found by Whyte on the Shire Highlands, called by Sir H. Johnstone the Malanje Cedar.

The South African species are *C. juniperoides*, the so-called Cape Cedar, and *C. cupressoides*, the Sapreehout. The former is a tree from 30 to 40 feet high, and occurs only on the Cedar Mountains, while the latter is only 10–12 or rarely 15 feet high, but is common on all the mountains of the South-Western districts. When recently he heard from Mr. E. Schwarz that he had seen "Sapree" trees in the Baviaanskloof mountains, which were 50–60 feet high, he suspected at once that this must be a different species, and applied to the Civil Commissioner at Willowmore, Mr. Hugo, for some ripe cones. Mr. Hugo having gone to the trouble of procuring these for him, he was enabled to ascertain that this tree is quite distinct from the common *C. cupressoides*. The cones resemble very much those of the Cape Cedar, but the seeds are more similar to those of the dwarf species, yet different.

Mr. E. **Hutchins**, exhibited Radium Scintillations in Crook's Spinthariscope, and Professor J. C. **Beattie** made explanatory remarks on the exhibit.

Mr. A. W. **Rogers** read a paper on "The Glacial Conglomerate in the Table Mountain Series near Clanwilliam."

This communication is an extension of one read before the Society in 1901. The conglomerate with glaciated pebbles has now been traced through a distance of about 23 miles near Clanwilliam. There was formerly some doubt as to whether the conglomerate was really interbedded with the sandstones and shales of the Table Mountain group, but this doubt has been removed by the finding of the conglomerate on the downthrow side of the Augsburg fault but on the same horizon as in the Pakhuis section.

By measurement at four localities the conglomerate is now known to occur at the base of the shale band, which is 300 feet thick, and to occupy approximately one-third of that band. Passages into both the underlying sandstone and the overlying shale have been observed.

The relationship of the shale band to the other parts of the formation, and the conditions under which the Table Mountain series was formed are discussed.

The following papers were taken as read:—

"South African Verbenaceæ—Supplementary note," by H. H. W. **Pearson**.

"Further Note on Factorisable Continuants," by **Thos. Muir**.

"South African Hymenoptera," by P. **Cameron**.

"On the Structure of the Endothiodont Reptiles," by R. **Broom**.

ORDINARY MONTHLY MEETING.

October 26, 1904.

Sir **David Gill**, K.C.B., F.R.S., Vice-President, in the Chair.

Rev. E. **Goetz**, Dr. H. **Becker**, and Messrs. E. **Oppenheimer** and F. **Weir**, were elected ordinary members of the Society.

Mr. B. E. O'**Meara** was nominated for election by Messrs. J. R. **Sutton** and L. **Péringuey**.

Professor H. H. W. **Pearson** exhibited two botanic specimens:—

I. *Arctopus monacanthus*, Carmich., a fruiting specimen from a locality near Vlottenburg Station, in the Stellenbosch District.

This species has a very local distribution, and until quite recently has been represented by incomplete specimens, if at all, in South African Herbaria. The male plant appears never to have been collected. It presumably exists, since the seeds of the plant exhibited appear to be fertile.

II. *Utricularia* sp. This small species was found on Muizenberg Mountain, in the Cape District, at about 400 feet. It is neither *U. capensis* nor *U. livida*, the only two species which, according to local records, occur on the Cape Peninsula. It was suggested that it might be *U. Ecklonii*, or, failing this, probably a new species. The specimens exhibited showed the leaves, stolons, and "bladders." in addition to flowers and capsules.

Dr. **Marloth** exhibited a species of aloe, found on the high mountains near Frenchhoek. He said that this was a new and undescribed species. The special interest which it possessed for botanists was the locality where it was found. The species of aloe and of the allied genera *Haworthia* and *Gasteria* were Eastern forms, and did not belong to the Cape flora of the South-west. Owing to their succulent leaves, they were specially adapted for existence in districts with dry periods, but, although the Western dry summer suited them very well, the winter was too wet for them, and many when planted decayed during the wet and cold weather. He drew attention to the great defect in our knowledge of the occurrences and distribution of these plants in the country, the habitat of most of them being given as South Africa. Any one finding plants of these succulents would greatly assist in increasing the knowledge of the distribution by sending specimens, with or without flowers.

Professor J. C. **Beattie** made a short communication of the methods adopted for the determination of radio-activity. He had had two specimens of earth or mud, Caledon Baths spring deposits, submitted to him by Mr. **Schwarz**, but he had not yet completed his investigations.

Mr. **Ernest** H. L. **Schwarz** gave a communication upon "The Rocks of Tristan d'Acunha, brought back by H.M.S. *Odin*, Commander **Pearce**, R.N., and their bearing on the question of the Permanence of Ocean Basins."

Through the courtesy of Commander **Pearce**, of H.M.S. *Odin*, a number of specimens were recently obtained for the South African Museum from the island group of Tristan d'Acunha. The islands are described in the *Challenger* Reports, and from the accounts published in them it is evident that while Inaccessible Island and Tristan d'Acunha itself are ordinary volcanic islands, Nightingale

Island is a gigantic agglomerate neck like those that the author has described from Griqualand East, on the flanks of the Drakensberg Mountains. Two rocks of a type unusual to volcanic islands were brought back by the expedition, and these call for a review of the facts already known about Oceanic Islands. Of the two rocks in question one was a white mica and biotite gneiss, from Tristan d'Acunha, the other a lava containing foreign fragments from Nightingale Island. In the Falkland Islands a number of rocks are found which are not only similar to the South African Bokkeveld Beds, but the fossils contained in them are the same. An identical fauna is found in Devonian rocks in South and North America, and it appears certain that the land from which the sediment was derived, which now contains these fossils, was continous through a great arc, from Cape Town to South and North America. The European Devonian fossils are quite different. The land connection between Africa and South America is confirmed by the evidence of the Jurassic Beds, and by the distribution of living animals. It is from a base made up of rocks which went to form this old continent that the volcanic cones of Tristan d'Acunha and Inaccessible Island rise, and through which the rocks burst that now go to form the agglomerate plug of Nightingale Island. St. Paul's Rocks, in mid-Atlantic, the Island of Rockall, of Mayo, in the Cape Verde Islands, the Canary Islands, Ascension, South Georgia, and Gaussberg, in the Antarctic, all contain rocks of a distinctly continental type, as well as the more conspicuous volcanic ones. In the West Indies there is also evidence that the volcanic islands rise from a submerged continental ridge. There are a number of legendary islands—Atlantis, Antilla, Brasil, and the famous Island of St. Brandan—which are supposed to have sunk beneath the water in comparatively recent years, but it is certain that these must owe their origin to pure invention. In the Pacific, New Caledonia is entirely of a continental type, but recently the truly volcanic islands of Fiji, which have been thought to be purely volcanic, have been shown to be built on a platform of old sedimentary beds. The Solomon Islands and the New Hebrides have likewise yielded, on close examination, extensive areas of old sedimentary rocks. The Tonga Islands, though no old sedimentaries show above sea-level, nevertheless the fine ash thrown out from the volcanoes shows that beneath the cones there are the same types of rocks as in Fiji and New Caledonia. Non-volcanic material brought up in the pipes of volcanoes is known from Italy, Germany, Scotland, and South Africa, and these afford evidence of the remarkably cool nature of some volcanic outbursts. In South

Africa, the Kimberley volcanic pipes must have brought the diamonds to the surface embedded in a cold matrix, for Luzi found that on keeping diamonds in a mass of melted blue-ground for half an hour the diamonds were intensely corroded. Chaper thought that the diamond pipes were formed by the escape of cold gases, like in the case of outbursts of sand in petroleum areas. The recent discovery of the German South Polar ship *Gauss* of quartz sand in mid-Atlantic points to a similar outburst beneath the sea. In Scotland and Germany volcanic vents are filled with limestone, which is hardly at all altered by heat, and the theory that volcanoes are pipes reaching to the molten interior of the earth must be abandoned. In Baviaan's Kloof, in the Cape Colony, there are large areas of Table Mountain sandstone, crushed up to the finest rock meal, and if the material had been more fusible the rock would have melted, and a volcano would have been produced. The Drakensberg volcanoes lie in a line of movement in the crust, and it is almost certain that the crushing that took place along this line melted the rocks, and thus produced the lavas. In the case of the Sutherland and Kimberley volcanoes, the vents lie on the north of the Karroo, the southern end of which is folded, the centre being occupied by dolerite intrusions; it is evident, therefore, that the expansion which the heated dolerite produced in the Karroo rocks found relief by buckling in the south, and shearing and consequent production of volcanoes on the north. It is thus plain that volcanoes and volcanic islands must have a base of older rocks, and that it is the melting of these that produces them. It is also proved that the lavas are not magmas brought for the first time to the surface of the globe from profound depths. Professor Vogt's researches show that the original rocks of the earth's crust, those that do come from great depths, are altogether different in nature to the volcanic series.

ORDINARY MONTHLY MEETING.

November 30, 1904.

Dr. J. D. F. GILCHRIST, President, in the Chair.

Messrs. B. E. A. O'MEARA, and R. POLLITT were elected ordinary members. Miss INEZ STEBBINS, B.A., and Mr. E. E. GALPIN, F.L.S., were nominated for election by Dr. BOLUS and Professor H. M. PEARSON, and Dr. FLINT and L. PÉRINGUEY.

Mr. E. HUTCHINS spoke on the recent developments on the adoption of the Metric System, and announced his intention to move a resolution in favour of the adoption of the same at the next Meeting of the Society.

A paper by Dr. R. **Broom** on "The Structure and Affinities of the Endothiodont Reptiles" was read. Dr. **Broom** opposes the view of Professor **Seeley** that *Tritylodon* was a Theriodont. His most important argument is that the structure of the molars proves that there was an anteroposterior motion for the mandible, and that this movement would only be possible with the mammalian type of articulation.

Mr. A. L. **du Toit** read a paper on the "Forming of the Drakensberg."

The Drakensberg is the edge of a great elevated tract of country built up of the sedimentary rocks of the Stormberg formation and capped by a great thickness of volcanic material.

The sediments were deposited in a great shallow lake, whose shore-line stretched where the coast-ranges of the south of the Colony now rise, extending eastwards into the Indian Ocean and then north-eastwards parallel to the coast-line of Natal. This old land surface was formed of quartzite of granite and metamorphic rocks.

The volcanic material was poured out from an immense number of volcanic pipes and consist almost entirely of basic lavas with occasional beds of volcanic ash, the flows being at first sub-aqueous in character.

At the close of the eruptions the area was affected by two sets of gentle folds and intermittently elevated. Through depression in the south-east the old land surface disappeared beneath the waters of the Indian Ocean.

By the action of rivers three marked plains of erosion were produced at different altitudes, each marking a period of rest followed by a period of elevation.

The present escarpment of the Drakensberg which runs continuously for over 300 miles is due to the regular and rapid erosion by the numerous streams flowing into the Indian Ocean.

ORDINARY MONTHLY MEETING.

February 22, 1905.

Dr. J. D. F. **Gilchrist**, President, in the Chair.

Messrs. A. H. **Wallis**, District Engineer, C.G.R., was nominated for election by A. **Young** and L. **Péringuey**; A. **Macco**, Mining Engineer, by R. **Marloth** and L. **Péringuey**; W. R **Dewar**, Government Entomologist, O.R.C., by J. **Lyle** and L. **Péringuey**; P. C. **Keytel**, Cape Town, by L. **Péringuey** and J. D. F. **Gilchrist**.

Miss **Inez Stebbins**, B.A., and Mr. E. E. **Galpin**, F.L.S., were elected ordinary members.

Mr. E. **Hutchins** spoke at length in favour of the adoption in the Cape Colony of the Metric System, and it was resolved that "a representative committee of the Philosophical Society wait as a deputation upon the Honourable the Premier to urge the introduction of a Bill to legalise the Metric System of weights and measures, and to provide for the compulsory adoption of the System on it being adopted by the British Parliament."

The following paper was read :—

"Some Results of Observations made with a Black Bulb Thermometer *in vacuo*," by J. R. **Sutton**, M.A., F.R.Met.S.

The object of this investigation is chiefly to ascertain some of the effects of various meteorological influences upon the indications of a black bulb thermometer *in vacuo* at Kimberley. The highest temperature observed during the seven years 1897–1903 was 170.5°; the annual average is almost 138°; the highest monthly mean is 153·3°, in December; the lowest 118·8°, in June and July. Days of high temperature in the sun are often dusty. A comparative investigation of the different meteorological elements shows that the highest temperatures in the sun occur when the sky is about half clouded. When the sky is clear, the excess temperature in the sun above that in the shade decreases as the quantity of aqueous vapour in the air increases. It also increases as the humidity increases. From which superficially antagonistic facts the author draws the conclusion that while the aqueous vapour absorbs the solar heat, the return terrestrial radiation is intercepted to an extent dependent upon the humidity of the air. The results obtained for Kimberley admit of a satisfactory comparison with those obtained in the Himalayas and elsewhere. The theory of Tyndall based upon the absorbing properties of aqueous vapour, and that of S. Arrhenius based upon the absorbing properties of carbonic acid are also considered.

ORDINARY MONTHLY MEETING.

March 29, 1905.

Dr. J. D. F. **Gilchrist**, President, in the Chair.

The following nominations were made: Messrs. J. **Cornish Bowden**, of Cape Town, by Mr. E. **Hutchins** and Professor H.

H. W. **Pearson**; L. **MacLean**, of Cape Town, by Mr. E. **Hutchins** and L. **Péringuey**; **Franklin White**, of Bulawayo, R. **Orpen**, M.L.A., of Douglas, L. E. **Taylor**, of Johannesburg, by Messrs. W. L. **Sclater** and L. **Péringuey**; J. W. **Jagger**, M.L.A., of Cape Town, by Dr. J. D. F. **Gilchrist** and L. **Péringuey**.

Messrs. A. H. **Wallis**, A. **Macco**, W. R. **Dewar** and P. E. **Keytel** were elected ordinary members of the Society.

A paper on "Results of Experiments on Table Mountain for Ascertaining the Amount of Moisture deposited from the South-East Clouds" was read by Dr. R. **Marloth**. The author states, in conclusion, that he wishes to point out once more that he does not consider the measurements given in his communications to represent real rainfall. In his first paper a quantity of 75 inches was mentioned for a certain period, while the table of the present communication shows a record of 48 inches for one month. Even if 90 per cent. of this quantity is discarded, the remaining 10 is still very largely in excess of the rainfall recorded on the ordinary gauge. The most sceptical critic must admit that this quantity of water gathered during the dry season of the year must exercise a considerable influence on the vegetation of the mountains as well as on the springs.

A communication from Mr. J. T. **Johnson** "On the Discovery of a Large Number of Stone Implements of Palæolithic Type at Vereeniging, Transvaal," was taken as read. The author describes and figures several types of stone implements of palæolithic type, some of which he considers to be verging on the neolithic.

ORDINARY MONTHLY MEETING.

April 26, 1905.

Dr. J. D. F. **Gilchrist**, President, in the Chair.

The following nominations were made: F. M. **Morris**, M.B., Cape Town, by Dr. J. **Maberly** and L. **Péringuey**; F. J. **Lawrence**, Steytlerville, by W. L. **Sclater** and L. **Péringuey**; J. **Denham**, and Dr. G. W. **Robertson**, by W. L. **Sclater** and L. **Péringuey**; J. **Burtt Davy**, F.L.S., by Dr. H. **Bolus**, and Dr. J. D. F. **Gilchrist**; T. A. **Sheppard**, and A. **Bodong**, by L. **Péringuey**, and W. L. **Sclater**.

Messrs. A. H. **Cornish Bowden**, L. **MacLean**, **Franklin White**, R. **Orpen**, L. E. **Taylor** and J. W. **Jagger**, were elected ordinary members of the Society.

Dr. H. **Bolus** exhibited some new plants, several of them collected at Elim, in the Bredasdorp District, and which he intended to describe in the *Transactions*.

Mr. J. Stuart Thomson exhibited a remarkable collection of Crustacea collected by the ss. *Pieter Faure*, with verbal notes on their distribution, &c.

Mr. C. F. Juritz, read a communication: "Some Notes regarding South African Pharmacology."

Half a century ago Pappe predicted that amongst the Cape Flora many useful drugs would be discovered, and he deplored the lack of scientific research. Since then there had been scarcely any progress and next to no application had been made of indigenous drugs except by the aborigines. The employment of plants possessing physiological action by native "doctors" had led to many indictments for culpable homicide, and the consequent chemico-legal investigations comprise the whole extent of scientific inquiry into the nature of the plant poisons of the Colony.

Up to the present the only published record of chemical investigation dealing with any of these poisons is Mr. Isaac Meiring's notes on *Mesembrianthemum tortuosum*, read before this Society in September, 1896.

The plants mentioned in the present paper have been far from exhaustively examined, either chemically or as to their physiological action: only so much scientific investigation has been made in each instance as proved necessary to elucidate the points required to be made clear for legal purposes.

Under this restriction the following plants have been examined: *Trichilia Dregei*, E. Mayer, which was said to have caused the death of a Kafir woman. Slender, needle-shaped crystals, not of an alkaloidal nature, were obtained from this plant.

Mesembrianthemum tortuosum, L., appeared to contain an essential oil which possessed a peppermint-like odour. The plant was apparently soporific, caused dilation of the pupil of the eye and lessened the sensibility thereof.

An undescribed species of *Gomphocarpus* was tested physiologically with negative results.

Fairly exhaustive tests were applied to needle-shaped crystals which constituted ⅛ per cent. of the bark of the "Umjela" tree (*Tabernæmontana ventricosa*, Hochst.) which is said to possess therapeutic properties rivalling those of Quinine. The most characteristic reaction was that yielded with Vitali's test, namely, a beautiful crimson lake colour, which appeared to be very delicate. The active principle seemed to be an as yet unknown alkaloid.

An uncrystallisable principle, apparently an alkaloid, was obtained from the bulb of *Buphane toxicaria*, Herb., which was the cause of death of two Kafir women. The bulb contained about ⅜ per cent. of this alkaloid, which physiologically resembled brucine but differed therefrom in its chemical reactions.

An unidentified root, which brought about the death of a native woman, yielded 1 per cent. of a resin which proved very rapidly fatal to mice.

Several examinations of *Acocanthera venenata*, Don, have been made, chemical and physiological. The plant is highly poisonous, paralysing the heart in systole. The most characteristic test for the active principle—evidently an uncrystallisable glucoside—appears to be concentrated sulphuric acid, which produces at first a yellow colour, changing into pink, then brick-red, and finally becoming violet.

A very energetic poison, probably a glucoside, was found in an unidentified bulb from Tsolo. The most characteristic physiological action appeared to be on the liver, which becomes much congested and softened. Chemically the action with sulphuric acid is very marked, a cherry-red colour being produced, changing into lake and then into light pink.

What seemed a non-crystalline glucoside was extracted from an unidentified plant which had been taken, with fatal result, by a native at Nqamakwe. Concentrated sulphuric acid here produced a bright vermilion colour, becoming in turn orange, yellow, and greenish yellow.

An acrid resin was obtained from *Polygonum tomentosum*, var. *glabrum*. With sulphuric acid a bright pink colour was produced changing through cherry-red and deep lake to a dirty brown, and then fading to a greenish tint. The resin acted as a strong depressant; it constituted 2½ per cent. of the dried root.

The paper concluded with an expression of regret that such important matters of research were only entered upon as side issues to criminal trials, and urged the necessity of considering such investigations as *per se* the recognised functions of the Government Analytical Laboratories.

ORDINARY MONTHLY MEETING.

May 31, 1905.

Dr. J. D. F. GILCHRIST, President, in the Chair.

The following nominations were made: H. S. HARGER, Johannesburg, by E. L. L. SCHWARZ and L. PÉRINGUEY; Dr. G. POTTS, B.S.Ph.D., Bloemfontein, by J. **Lyle** and L **Péringuey**; J. S. **Backhouse**, B.A., Cape Town, by J. **Hammond Tooke** and J. D. F. **Gilchrist**; F. **Pickering**, Cape Town, by M. **Wilson** and L. **Péringuey**; Dr. E. C. **Long**, Maseru, by W. L. **Sclater** and L. **Péringuey**.

Messrs. F. M. **Morris**, F. J. **Lawrence**, J. **Denham**, J. **Burtt-Davy**, P. A. **Sheppard**, A. **Bodong**, G. W. **Robertson** were elected ordinary members of the Society.

A notice of the late Dr. E. W. **Cohen**, honorary member of the Society, was read by Mr. E. H. L. **Schwarz**.

Professor Dr. Emil Wilhelm Cohen was born in Aakjaer, Jutland, in 1842. He came out to the Cape in 1872 at the request of Messrs. D. Lippert, of Hamburg, to make a thorough examination of the diamond-fields; the investigation was later undertaken of the gold-fields of Marabastad and Lydenburg. During his stay of four months in South Africa he sent home several letters to Professor Leonhard, which were published in what is now known as the *Neues Jahrbuch*, in one of which there is the first suggestion of the volcanic origin of the Kimberley pipes, and when he returned he published, in the same Journal, several very important papers on the general geology of South Africa, under the title "Geognostisch petrographische Skizzen aus Sud-Afrika." The diamond-fields were described in the Fünfte Jahresbericht des Vereins fur Erdkunde zu Metz. As a mineralogist he investigated the diamondiferous blue, the Rand banket, the Drakensberg lavas, and many other typical South African rocks, and published the first descriptions of them, while later, when he took up meteorites as a speciality, all the known South African falls were examined by him. His papers, throughout, were characterised by a wish that he should see more of the country which supplied him with such rich materials for research, and he was, therefore, overjoyed to receive an invitation to visit the Cape in connection with the British Association, and geologists in South Africa were hoping to welcome the protagonist of many of the great controversies which still occupy their thoughts. At the time of his death he was engaged in the description of the St. Mark's Meteorite, the property of the South African Museum, which was, however, sufficiently advanced to allow of its completion by his friend Dr. W. Deecke.

Dr. R. **Marloth** exhibited specimens of an undescribed tree from the Roggeveld, and said: This plant is remarkable for several reasons:

1. Because it is a tree, for the Roggeveld is known as an absolutely treeless country, the vegetation consisting of low

bushes, hardly more than 2 or 3 feet high. There is no other wood available as fuel than such brushwood.

2. Because this is a species of *Cliffortia*, or a new genus nearly allied to it. But the genus *Cliffortia*, is one of the most characteristic types of the South-western flora of the Cape, hence we see that the only tree of the group occurs as an isolated outlier on the mountains beyond the Karroo.
3. On account of the far more xerophilous structure of the leaves than on any other species, being well protected against excessive transpiration by a thick coat of peculiar hairs, which form a real fur.

The tree reaches a height of 25 feet and has a trunk up to 20 inches in diameter. It grows only on the upper edge of the Komsberg (5,200 feet) and the Southern end of the Roggeveld mountains.

The colonists call it "starboom," on account of the peculiar arrangement of the leaves.

It is probable that the thick fur on the leaves absorbs moisture from the clouds which strike against the edge of the mountains in their northward course, and that this has enabled the tree to remain in this particular locality as one of the few traces of a formerly moister climate and a wider stretch of the real Cape flora.

Mr. L. **Péringuey** read a Note on the agent of a new "Myasis," or disease caused by flies:—

About a fortnight ago Dr. Ashley-Emile asked him to examine some minute grubs which he had brought from Northern Rhodesia, and which he thought were the cause of this very nasty disease called the Veld sore, and also Natal or Delagoa Bay sore. On examination it was found that the Doctor's surmise was justified—the grubs proving to be those of a Dipterous Fly. They are very minute; the body segments are covered with sharp hooked spines, enabling the grub to hold firmly where it has penetrated, and the animal would, in this wise, cause a very great irritation. It is totally unlike the grub of *Bengueyella depressa* deposited on the body of man, or even, it is said, of dogs in Natal, the Transvaal, Delagoa Bay, and also in Senegal, and which he had on two occasions brought to the notice of the Society. As Dr. Ashley-Emile intends, however, to bring out his discovery of the agent of this new myasis before a medical society, he refrained to add any more details on these grubs, but, while endeavouring to ascertain the identity of the animal, he found that Livingstone had been a victim of a fly, not identical with but similar to that discovered by

Dr. Ashley-Emile. The larva extracted from Livingstone's leg by his companion, Dr. J. Kirk—later on Sir John Kirk—was given by him to Cobbold, and deposited by the latter in the Collection of the Royal College of Surgeons. It has been figured by Blanchard, and the drawings were exhibited.

A paper, "Notes on Semicirculants," by **Thos. Muir**, LL.D., was read.

Dr. **Marloth** read a short paper on "Further Observations on Mimicry among Plants," from which he draws the conclusion that those plants which are best hidden on the bare veld owing to their colour and shape have the best chance of escaping destruction, while others which are more conspicuous on the ground will be more readily detected and eaten up, and that the theory of coincidences is hardly admissible.

Mr. J. **Stewart** read an abstract of a paper by J. R. **Sutton** on "The Variation of the Hourly Meteorological Normals at Kimberley during the passage of a Barometric Depression."

He stated: This paper is the result of an attempt: (1) to determine the variation of the hourly normals of the more important meteorological elements at Kimberley introduced by the passage of a barometric depression; and (2) incidentally to learn something of the conditions prevailing in the depression itself. The investigation is based almost entirely upon observations made at a single station, information suitable for the construction of synoptic charts not being available.

The ordinary depression may last any time from a day to a week, and the winds generated may blow with any velocity up to 35 miles an hour, and perhaps to 50 miles an hour in occasional gusts. When they first become noticeable to all by reason of the strength of the wind, they set in with warm and discomforting gusts from the North or North-west, and pass away with cool, steady winds from South-west or South. They often bring light showers, but not often heavy rain. Frequently the approach of the centre or trough is heralded by clouds of dust; but it is remarkable that equally strong winds in the rear of the centre seldom raise any dust to speak of.

A selection of 105 depressions has been made from those which passed over Kimberley in the six years, 1898–1903, and the hourly changes of pressure, temperature, vapour-tension, rain, and wind, in them compared with the normal averages of the same elements. The paper being chiefly preliminary to a more extended treatment later on, no distinction at this stage has been thought necessary between the different types of depression.

Winter depressions are larger and more pronounced than those of summer; but at no time are the ordinary diurnal curves obliterated, although they are modified in a very interesting way by barometric disturbances. The average maximum deviation of pressure from the mean, in the 105 cases made use of, is just about one-seventh of an inch. Directly in front of the trough of a depression the temperature averages 2° higher than usual; there is a slight increase of the vapour contents of the air, and of the clouds. In the immediate neighbourhood of the trough the velocity of the wind increases considerably; also the rain-frequency and intensity are both greatly augmented. In the rear of the depression it is colder and drier, and the wind, though strong, is steadier and less dusty. The paper shows that the variations in the velocity of the wind may be partly explained as a combination of the normal winds with the cyclonic winds of the depression.

The curve showing the variation of the resultant wind-direction during the passage of a depression is of much interest. It seems that the east component is very little affected, and that the departure from the mean falls almost entirely upon the north component. Taken in conjunction with the fact that the east component curve is essentially a curve of temperature, this result is important. Another result is that the extremity of the direction-resultant veers at all times in conformity with the normal curve. The prevailing direction of motion of these depressions is from south-west to north-east across the central tableland, and they reach Kimberley and Durban some twenty to forty hours after passing over Cape Town.

ORDINARY MONTHLY MEETING.

June 28, 1905.

Dr. J. D. F. **GILCHRIST**, President, in the Chair.

The following nominations were made: Messrs. J. G. **CAINK**, Cape Town, by E. H. L. **SCHWARZ** and A. L. **DU TOIT**; J. **FFOLLIOTT DARLING**, Bulawayo, by W. L. **SCLATER** and L. **PÉRINGUEY**; J. **JEPPE**, Cape Town, by R. **MARLOTH** and L. **PÉRINGUEY**.

Messrs. H. S. **HARGER**, Dr. G. **POTTS**, J. S. **BACKHOUSE**, F. **PICKERING**, and Dr. E. C. **LONG** were elected ordinary members of the Society.

Mr. W. L. **SCLATER** exhibited the remains of the boundary beacon erected on the Zeekoe River, in what is now the Colesberg District, in the year 1778, by the Governor, Joachim van Plettenberg. The remains of the stone bearing the arms, date, and part of the name of the Governor, were found some years ago by Messrs. Murray Bros., of Quaggafontein, Colesberg Division, and have recently been placed in the South African Museum.

Mr. A. W. **Rogers** read a paper on the "Volcanic Fissure under Zuurberg." On the south flank of Zuurberg the Uitenhage beds are faulted down against the folded rocks, forming the Zuurberg. The fault runs nearly parallel to the strike of the older formations, the Wittberg quartzite and the Dwyka series. The fault between Enon and Duncairn, a distance of 19 miles, is marked by a belt of volcanic rocks, lava, tuffs, and breccias, varying in width from 100 yards to over a mile. Three definite necks of tuff and breccia have been recognised, but the eruption took place along the whole line in such a way that the lavas are at places full of tuff fragments, but the tuffs do not contain pieces of the lava. Where the volcanic rock does not appear, as on the Waggwa road, the rocks immediately on the upthrow side of the fault are shattered; a perfect series of gradations from solid, unbroken quartzites to quartzite-breccia with a matrix of the same substance, has been observed within the distance of 30 yards. These facts call to mind the shattering of the rocks along the faults on the north boundary of the Uitenhage outliers of Willowmore and Uniondale, observed by Mr. Schwarz, and they probably indicate explosive action along the lines of faulting.

A paper on the South African Denosaur "Hortalotarsus" by Dr. R. Broom was read.

ANNUAL GENERAL MEETING.

August 2, 1905.

The **President**, Dr. J. D. F. **Gilchrist**, in the Chair.

The **Secretary** read the General Report for the year 1904–1905.

The **Treasurer** read his statement, showing a balance to the credit of the Society of £250 3s.

Dr. J. C. **Beattie** was elected President for 1905–1906, and Messrs. J. D. F. **Gilchrist**, C. P. **Lounsbury**, H. H. W. **Pearson**, L. **Péringuey**, and W. L. **Sclater**, were elected members of the Council for two years.

The Meeting they resolved into an Ordinary Meeting. Messrs. J. G. **Caink**, J. **ffolliott Darling**, and J. **Jeppe** were elected ordinary members of the Society.

REPORT OF THE SECRETARY FOR THE YEAR 1904–1905.

Eight ordinary meetings and one general meeting have been held during the year.

Eighteen papers have been read, and they have either been printed or are in the printer's hands, viz.:—

A. W. Rogers, "The Glacial Conglomerate in the Table Mountain Series near Clanwilliam.

H. H. W. Pearson, "South African Verbenaceæ."

T. Muir, "Further Note on Factorisable Continuants."

P. Cameron, "Description of new South African Hymenoptera."

E. H. L. Schwarz, "The Rocks of Tristan d'Acunha and their bearing on the Question of the Permanence of Ocean Basins."

R. Broom, "The Structure and Affinities of the Enthodion Reptiles."

A. L. du Toit, "The forming of the Drakensberg."

J. R. Sutton, "Some Results of Observations made with a Black Bulb Thermometer."

R. Marloth, "Results of further Experiments on Table Mountain for ascertaining the amount of Moisture deposited from the South-East Clouds.

C. F. Juritz, "Some Notes regarding South African Pharmacology."

J. P. Johnson, "On the Discovery of a Large Number of Implements of Palæolithic type at Vereeniging, Transvaal."

H. Bolus, "Contributions to the African Flora."

T. Muir, "Notes on Semicirculants."

R. Marloth, "Further Observations on Mimicry among Plants."

J. R. Sutton, "On the Variation of the Hourly Meteorological Normals at Kimberley during the Passage of a Barometric Depression."

A. W. Rogers, "The Volcanic Fissure under Zuurberg."

W. L. Sclater, "On the Remains of van Plettenberg's Boundary Stone from Colesberg."

R. Broom, "On Hortalotarsus."

The Society has issued during the year (June to June) part 1 of vol. XIII.; parts 1, 2, 3, 4 of vol. XV. and part 1 of vol XVI., or 600 pp. and 18 plates. Part 5, which completes vol. XV., is expected here towards the middle of August.

Ten members resigned during the year; 2 died, 10 have been removed from the list for arrears in their subscription, 29 have been elected. The Society numbers now 229 ordinary and 3 honorary members. The sale of publications for the year amounts to £80 11s.

L. Péringuey, *Hon. Secretary.*

TREASURER'S STATEMENT.

THE HON. TREASURER IN ACCOUNT WITH THE SOUTH AFRICAN PHILOSOPHICAL SOCIETY, JULY 1, 1904, TO JUNE, 30, 1904–5.

RECEIPTS.

	£	s.	d.	£	s.	d.
To Balance in Bank, on fixed deposit at 3½ per cent.	250	0	0			
,, Floating Balance in Bank, as per Bank Book	35	14	8			
,, Cash in hand not paid into Bank by June 30, 1904	20	6	9			
,, Petty Cash Balance	6	16	7½			
				312	18	0½
,, Subscriptions—						
1 full subscription, Town, 1902	2	0	0			
2 ,, subscriptions, Town, 1903	4	0	0			
5 ,, ,, Country, 1903	5	0	0			
19 ,, ,, Town, 1904	38	0	0			
20 ,, ,, Country, 1904	20	0	0			
79 ,, ,, Town, 1905	158	0	0			
72 ,, ,, Country, 1905	72	0	0			
Fractional Subscriptions of New Members and Odd Shillings Sent to Cover Exchange, &c.	9	2	5			
23 Entrance Fees	23	0	0			
				331	2	5
,, Interest on £250 at fixed deposit at 3½ per cent.				8	15	0
,, 7 Subscriptions* to Refreshment Fund for Special Meeting and Reception to Medical Congress on December 29, 1900				2	7	3
,, Sale of Society's Publications				80	11	0
				£735	13	8½

EXPENDITURE.

	£	s.	d.	£	s.	d.
By Publications—						
Messrs. West, Newman & Co., for Printing—						
Vol. XIII., pp. 1–293	£108	3	0			
Vol. XIV., Title and Contents	1	10	0			
Vol. XV., pt. 1	50	6	6			
Vol. XV., pt. 2	30	16	6			
Vol. XV., pt. 3	66	8	0			
Vol. XV., pt. 4	81	0	6			
				338	4	6
,, Local Printing and Typewriting of Notices and Minutes of Meetings, &c.				24	5	10
,, Freight on Publications				16	6	3
,, Stationery				5	9	6
,, Rent for Library, July, 1904, to June, 1905				36	0	0
,, Caretaker for Library, January, 1904, to December, 1904				5	0	0
,, T. D. Butler for Clerical Assistance, April, 1904, to June, 1905				6	5	0
,, Compilation of International Catalogue of Scientific Literature				10	0	0
,, Postage Stamps				34	2	6½
,, Refund to Dr. Marloth for outlay on Rain-gauges				4	8	0
,, Mr. Clarke for Magic Lantern at Annual Meeting				2	2	0
,, Petty Expenses and Bank Charges				3	7	1
				485	10	8½
,, Balance in Bank on fixed deposit at 3½ per cent.	£175	0	0			
,, Floating Balance in Bank, less £15 (being a cheque issued in June, 1905, but not cashed until July by the recipient)	72	4	6			
,, Petty Cash Balance	2	18	6			
				250	3	0
				£735	13	8½

We, the undersigned members of the South African Philosophical Society, hereby declare that we have examined the above account, compared the Receipts with the Counterfoils of the Receipt Book, the Cash Payments with the Vouchers and the Balance with the Bank Pass Book, and have found the same correct.

(Signed) ARTHUR W. ROGERS,
ALEX. L. DU TOIT, } *Auditors.*

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* Two Subscriptions are still outstanding.

ADDITIONS TO THE LIBRARY.

ADELAIDE.

Proceedings of the Royal Geographical Society of Australasia. South Australian Branch, vol. vii. Session 1903–4.

Transactions and Proceedings and Report of the Royal Society of South Australia, vol. xxviii.

Meteorological Observations made at the Adelaide Obs. during the year 1900–1901.

AGRAM.

Jahrbuch des Meteorologischen Observatorium 1902.

AMSTERDAM.

K. Ac. Van Vet. te Amsterdam.

Proceedings of the Section of Science, vol. vi.

BALTIMORE.

Johns Hopkins Hospital Bulletin, Nos. 157, 158, 159, 162, 163, 165, 166, 167, 168, 164, 160, 161, 169, 170.

Johns Hopkins University Studies, series xxi., Nos. 1–12; series xxii., Nos. 1–12; series xxiii., Nos. 1, 2.

Johns Hopkins University Circulars, 1903–4, No. 1; 1904, Nos. 1–8; 1905, Nos. 1, 2.

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Verhandlungen der Naturforschenden Gesellschaft, Band xvii.; Band xv., Heft 3.

BERKELEY, U.S.A.

Publications of the University of California.

- Botany, vol. ii., pp. 1–171.
- Pathology, vol. i., No. 1.
- Zoology, vol. i., Nos. 3, 4, 5, 6, 7.
- Bulletin, Nos. 149–154.
- Bulletin, vol. v., Nos. 2, 3; vol. vi., Nos. 1, 2.
- Report of the work of the Agricultural Experimental Station.
- American Archæology and Ethnology, vol. ii., No. 4.

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Deutsche Entomologische Zeitschrift, J. 1904, H. 2.

Sitzungsberichte der Kön. Preuss. Akademie der Wissenschaften, pts. xxii.–xl., 1904; pts. xli.–lv., 1904; pts. i.–xxii., 1905.

BOULDER, COLORADO, U.S.A.

The University of Colorado, Studies, vol. ii., Nos. 2, 3.

BRUSSELS.

Académie Royale de Belgique.

Bulletin de la Classe des Sciences, Nos. 5, 6, 7, 8, 9, 10, 11, 12, 1904; Nos. 1, 2, 3, 4, 1905.

Annuaire, 1905.

BUENOS AYRES.

Anales del Museo Nacional de Buenos Aires, series iii., tom. iii. 2.

CALCUTTA.

Proceedings of the Asiatic Society of Bengal, No. xi., 1903; Nos. 1–5, 1904.

Journal of the Asiatic Society of Bengal, vol. lxxii., pts. 1, 2, 1903; vol. lxxiii., pt. 1, Nos. 1, 2, 1904; vol. lxxiii., pt. 2, Nos. 1, 2; vol. lxxiii., pt. 3., Nos. 1, 2.

CAMBRIDGE, ENGLAND.

Cambridge University Library.

Report of the Library Syndicate, 1903.

Proceedings of the Cambridge Philosophical Society, vol. xii., pt. 6; vol. xiii., pts. 1, 2.

CAPE TOWN.

Report of the Govt. Biologist for half-year ending 1904.

Marine Investigations in South Africa, vol. ii.

Report of the Senior Analyst for 1904.

Annals of the Cape Obs., vol. ix.

Report of His Majesty's Astronomer at the Cape for 1903.

Report of the Government Botanist for half-year 1904.

Annals of the South African Museum, vol. iii., pt. 6.

Minutes of Proceedings of the Cape Society of C. E., vol. 1, 1903.

CHICAGO, U.S.A.

Field Columbian Museum, vol. iii., Nos. 15, 16.

Zoological Series, vol. iv., pt. 2; vol. v.

Geological Series, vol. ii., Nos. 5, 6.

Botanical Series, vol. 2, No. 2.

Report Series, vol ii., No. 3.

CINCINNATI.

Journal of the Cincinnati Society of Natural History, vol. xx., No. 4.

COLORADO SPRINGS, COLORADO.

Colorado College Studies, General Series, Nos. 13, 14, vol. xi., pp. 54–85, 85–118.

DAVENPORT, U.S.A.

Proceedings of the Davenport Academy of Sciences, vol. ix.

EDINBURGH.

The Scottish Geographical Magazine, vol. xx., Nos. 8, 9, 10, 12; vol. xxi., Nos. 1, 2, 3, 4, 5.

Proceedings of the Royal Physical Society, vol. xvi., Nos. 1, 2.

GENOA.

Annali del Museo Civico di Storia Naturali di Genova Serie 3ª, vol. i.

GLASGOW.

Proceedings of the Royal Philosophical Society, vols. xxxv., 1903–4.

GÖTTINGEN.

Nachrichten von der Königlichen Gesellschaft der Wissenschaften zu Göttingen.

Mathematische-Physicalische Classe, 1904, Nos. 3, 4, 5, 6.

Geschäftliche Mittheilungen, 1904, Heft 2.

HAMBURG.

Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten, xxi; Jahrgang, 1903; Beiheft 1, 2, 3.

HAMILTON, CANADA.

Journal and Proceedings of the Hamilton Scientific Association, 1903–4.

INDIANAPOLIS.

Proceedings of the Indiana Academy of Science, 1903.

JOHANNESBURG.

Transactions of the Geological Society of South Africa, vol. viii.

E. T. Mellor (Reprints from T.G.S.A.).

Outliers of the Karroo System.

Waterberg Sandstone.

On some Glaciated Land Surfaces.

LA PLATA.

Pub. de la Univ. de La Plata Pallontologia Argentina, No. 2.

Demografia, 1901.

LAUSANNE.

Bulletin de la Société Vaudoise, Nos. 150, 151.

LAWRENCE, KANSAS, U.S.A.

Bulletin of the University of Kansas.

Science Bulletin, Nos. 10–15.

Leipsic.

Berichte über die Verhandlungen der K. S. Gesellschaft der Wissenschaften zu Leipsic.

Math.-Phys. Classe. Jahre 1878–1890, 1895–1904.

Abhandlungen der R. S. Gesellschaft der Wissenschaften.

Math.-Phys. Classe, vols. xi.–xiv.; vols. xvi.–xxviii.; vol. xxix., Nos. 1, 2.

Register zu der Jahre 1846–1885.

Der Berichte über die Behandlungen der Math.-Phys. Classe der R. S. Gesellschaft der Wissenschaften.

Lima.

Boletin del Cuerpo de Ingenieros des Minas del Peru, Nos. 3, 4, 6–13, 15–19.

Boletin de la Sociedad Geographica de Lima, t. xv.

Lisbon.

Boletim da Sociedade de Geographia de Lisboa, 22ª Serie, 1904, Nos. 7–12; 23ª Serie, 1905, Nos. 1, 2.

London.

International Catalogue of Scientific Literature, 2 vol. A, B, C, D, F, G, H, J, K, L, M, O, P, Q; 3 vol. A, B, C, E, R.

Proceedings of the London Royal Society, No. 504; series A, vol. lxxvi., No. A, 507, 508; series B, vol. lxxvi., No. B, 507, 508.

Proceedings of the London Zoological Society, vol. i., pts. 1, 2; vol. ii., pt. 1.

Minutes of Proceedings of the Institution of Civil Engineers, vols. clvi., clvii., clviii., and clix.

List of Members of the Institution of C.E., 1904.

Proceedings of the Royal Colonial Institute, vol. xxxv., 1903–4

Quarterly Journal of the Royal Meteorological Society, Nos. 131, 132, 133, 134.

Quarterly Journal of the Geological Society, Nos. 239, 240, 241.

List of the Geological Society, 1904.

Report of the British Association for the Advancement of Science, vol. Cambridge, 1904.

Report of the Corresponding Societies' Committee of the B.A.A.S.

Royal Astronomical Society.

Monthly Notices, lxiv., Nos. 8, 9; lxv., Nos. 1, 2, 3, 4, 5, 6.

Memoirs, vol. liv., 5 Appendices; lv., 1 Appendix.

The Geographical Journal, vol. xxiv., Nos. 1, 2, 3, 4, 5, 6; vol. xxv., Nos. 1, 2, 3, 4, 5.

Second Report of the Geological Survey of Natal and Zululand.

Catalogue of the Science Collection for Teaching and Research in the South Kensington Museum, vol. i., Mathematics and Mechanics.

Reports of the Board of Education, 1902–3, 1903–4.

Report for the year 1903 of the Victoria and Albert Museum, Royal College of Science and Art, the Geological Survey and Museum, and on the Solar Physics Committee.

MADISON, WISCONSIN, U.S.A.

Transactions of the Wisconsin Academy, vol. xiii., pt. 2; vol. xiv., pts. 1, 2.

MANCHESTER.

Memoirs and Proceedings of the Manchester Literary and Philosophical Society, vol. xlviii., No. 3; xlix., Nos. 1, 2.

Journal of the Manchester Geographical Society, vol. xix., 7–12; vol. xx., 1–3, 4–6.

MARSEILLES.

Annales de la Faculté des Sciences, t. xiv.

MELBOURNE.

Proceedings of the Royal Society of Victoria, vol. xvii., pts. 1, 2.

MEXICO.

Memorias y revista de la Sociedad Scientificia Antonia Alzate, t. xiii., Nos. 7, 8; t. xviii., No. 6; t. xix., Nos. 6, 7, 8, 9, 10, 11, 12; t. xx., Nos. 5, 6, 7, 8, 9, 10, 11, 12.

Secretaria de fomento.

Parergones del Instituto Geologico, t. i., Nos. 1, 2, 3, 4, 5.

Boletin Mensual del Observatorio Meteorologico, April, May, August, 1902.

MISSOULA, MONTANA, U.S.A.

Bulletin, 19, 21, 22, 23.

MONTE VIDEO.

Anales del Museo Nacional, Serie ii., Entr. 1, 2.

Seccion Historico Filosofica, t. i.

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Bulletin de la Société des Naturalistes, 1903, No. 4; 1904, Nos. 1, 2, 3.

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Bulletin de la Société des Sciences naturelles de l'ouest de la France, 2ᵉ Ser., t. iii., 3ᵉ, 4ᵉ Trim., 1903; 2ᵉ Ser., t. iv., 1 and 2 Trim., 1904.

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Rendiconti dell' Accademia delle Scienze Fisiche e Matematiche, Ser. iii., 3ᵃ, vol. x., Fas. 1–12; Ser. 3ᵃ, vol. xi., Fas. 1, 2, 3.

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Revue Mensuelle, Nos. 406–415.

PHILADELPHIA, U.S.A.

Proceedings of the American Philosophical Society, Nos. 175, 176, 177, 178.

Proceedings of the Academy of Natural Sciences, vol. lvi., pts. 1, 2.

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TRANSACTIONS

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VOL. XVI.

THE GLACIAL CONGLOMERATE IN THE TABLE MOUNTAIN SERIES NEAR CLANWILLIAM.

By A. W. ROGERS.

(Read September 28, 1904.)

Four years ago I laid before the Society some evidence of glacial action in the Table Mountain series from the Pakhuis Pass near Clanwilliam. I have lately had an opportunity of searching the western flank of the Cederberg range for more outcrops of the conglomerate, and I traced the rock in question over an area fifteen miles in length and about seven in width. The total length of the lines along which the conglomerate has been followed, including the frequent intervals between outcrops, where the rock is concealed beneath the soil and fallen *débris*, is twenty-three miles. Even where the rock itself is not visible the form of the ground indicates its presence.

A visit to the Pakhuis Pass was not rewarded by the finding of any additional exposures to those described in the earlier communication.

From Botha's Berg the clearly-marked feature on the mountain slope, caused by the presence of the shale band, at the base of which the conglomerate occurs, was followed west-north-west through Rheebok's Vley, Vark Fontein Extension, Klein Vley Extension, Klein Vley, Zand Kraal Extension, to Lange Kloof, on the

Olifant's river, where the horizon is traversed by that river. There are two places along this line of country where the conglomerate can be well seen. One of these is on Klein Vley, in some dongas cut by storm-water from Mount Synnott. At the lower end of the dongas, near the Vark Fontein road, the ordinary, rather coarse, sandstones of the Table Mountain series, containing a few white quartz pebbles, are seen, but the actual junction with the overlying conglomerate is not exposed. The beds dip at an angle of about 10° to the north-east. In the dongas a vertical thickness of some forty feet of conglomerate is laid bare. The rock is much weathered, and is yellowish-red in colour. The matrix is a sandy mudstone without lamination planes. The majority of the enclosed pebbles are micaceous clayey sandstones, often thinly laminated. This rock resembles the sandstones of the Ibiquas beds more closely than any other known to me. Pebbles of quartz and quartzite are fairly abundant in this locality, but no fragments of granite or other igneous rock were met with. The pebbles range up to eight inches in length. Only a few of them were found to be striated, and these were of small size. The upper part of the conglomerate and the shale above are hidden by the *débris* from the Mount Synnott escarpment.

On the farm Lange Kloof, just below the boundary between it and Zand Kraal Extension, a short kloof has been cut back from the Lange Kloof river along the shale band, and there are several outcrops of the conglomerate in the upper part of the kloof, while yellowish-red, thinly-laminated sandy shales are seen to lie above the conglomerate. The sandstones below are similar to those at Klein Vley Extension, and the conglomerates at the two places are very much alike. The conglomerate at Lange Kloof is eighty feet thick, and over two hundred feet of shales lie between it and the overlying sandstone, which is a coarse, false bedded rock with scattered quartz pebbles. Several small scratched stones were found in the conglomerate here.

Near the boundary between Klein Vley and Groot Patrys Vley there is a conical hill, oval in plan, above the left bank of the Kliphuis river. The base of the hill consists of the sandstones below the shale band, which forms an elliptical area, and above the shale band there is an outlier of the upper sandstones. There are many outcrops of conglomerate and shale round this hill, and the passage from the unbedded mudstone with pebbles, about one hundred feet thick, through twenty feet of laminated shale with pebbles, to the thinly-laminated shale without pebbles, of which there are some two hundred feet, can be found without much difficulty in the numerous small ravines on the steep slopes of the hill. Pebbles up to fifteen inches in length are embedded in the mudstone at the bottom of the outlier, and striated stones can be obtained. Most of the pebbles are water-worn and well-rounded, but striations occur on many of those as well as on the subangular pieces of rock. The lowest portion of the conglomerate here is red, and the colour seems to be an original feature; the upper part, and the shales above, are yellowish at the surface and greenish within. The usual colour of the shales in the Table Mountain series is red, but both the shales and the conglomerate of Pakhuis are greenish when unaffected by the weather.

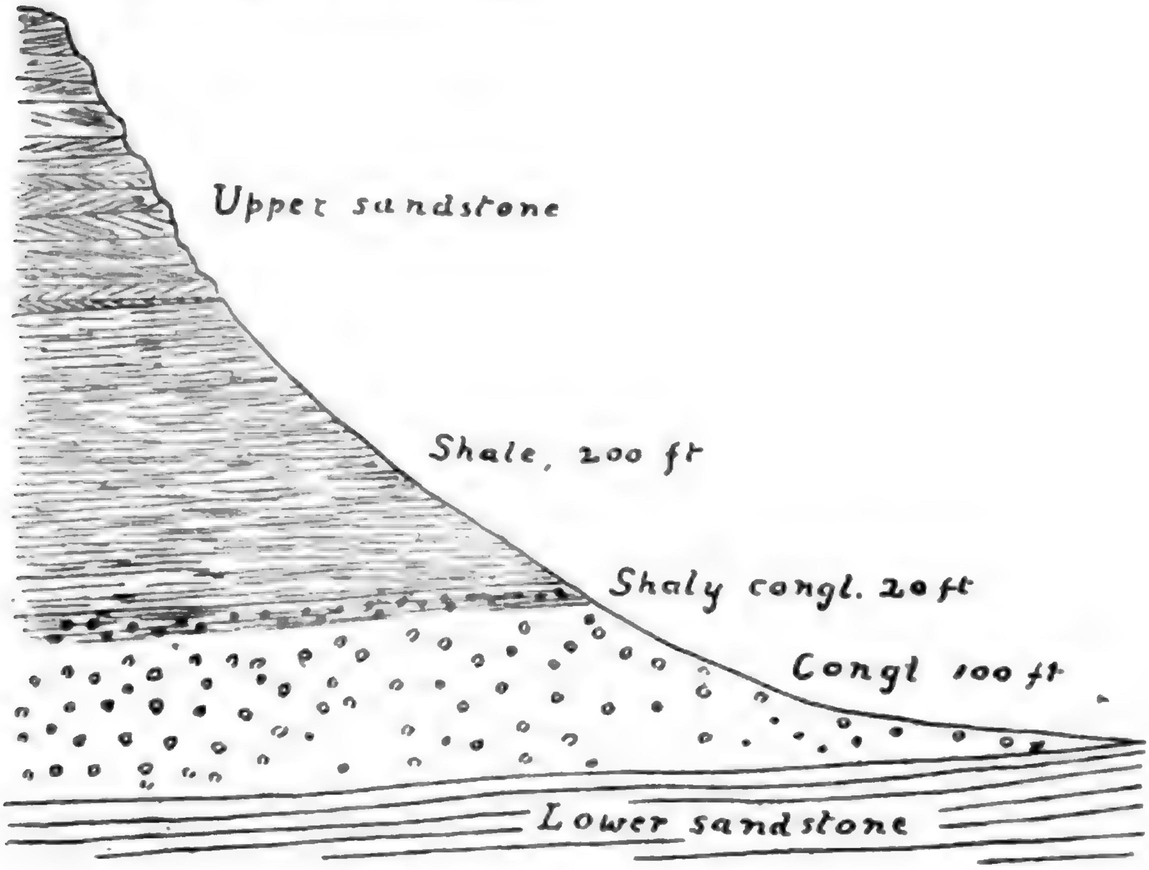

FIG. 1.—Section through south-west side of outlier on boundary of Klein Vley and Groot Portrys Vley.

South-east of the outlier on Klein Vley the sandstones below the shale band form a great area on the western slope of the Cederbergen; between Lange Kloof and the path to Krakadouw these lower sandstones abut against beds belonging to a higher horizon along the Augsburg fault. On the south-west side of the Jan Dissel's river the shale band crops out again, but it is here on the downthrow side of the Augsburg fault. I followed it across the watershed between the Jan Dissel's and Keurbosch Kraal river for a distance of over five miles along the outcrop, and it can be seen to extend far to the south, though it becomes thinner in that direction. The total thickness of the shale band in this neighbourhood is three hundred feet, of which the lowest hundred feet are of reddish-yellow weathering conglomerate. In the two kloofs cut along this horizon, which lead north to the Jan Dissel's river and south to the Keurbosch Kraal river respectively, there are many very good exposures of all parts of the conglomeratic rock, including the passage beds into the underlying sandstones on the one hand and the overlying shales on the other. The coarse sandstone below becomes more and more argillaceous towards its upper limit, and the included pebbles increase in numbers and variety, till within a vertical distance of twenty feet from the normal type of sandstone the rock assumes the character of the Pakhuis conglomerate. The passage upwards into the shales without pebbles comes about by the gradual decrease in numbers of the pebbles and the greater frequency of lamination planes in the sandy mudstone towards the top of the conglomerate. Pebbles of quartz, quartzites of three kinds, sandstones, felspathic grits, diabase, amygdaloidal rocks of the Zeekoe Baard type, and granite were noticed in these exposures, and several of them are flattened on one or more sides, and well striated. A dozen pebbles, from two to five inches in length, showing characteristic glacial striations, were found in this locality during the three hours I spent on the five miles of country between the two rivers mentioned above. Some very good exposures of the conglomerate, thirty feet in height and many yards long, can be seen on the banks of the stream entering the Keurbosch Kraal river. The pebbles are scattered quite irregularly through the sandy mudstone, which has a purplish colour; they are hardly abundant enough to give the rock the appearance of a conglomerate on a casual inspection, and areas of many square feet show no pebbles.

In the former communication on this subject it was pointed out that though the evidence given therein was sufficient to justify the belief that the glacial conglomerate really belonged to the Table Mountain series, and was not an outlier of the Dwyka conglomerate to which it had some resemblance, further facts to prove its stratigraphical position were desirable. These later observations place the conclusion then arrived at beyond dispute. In each of the localities described above the position of the conglomerate is the same, viz., at the base of the shale band, and in each place, so far as one can judge from the not very satisfactory sections, the conglomerate forms about a third of the thickness of the shale band. The gradual passage from the lower sandstones into the conglomerate on Bosch Kloof is clear evidence as to the relationship of the two rocks, and the passage upwards into the shale without pebbles has been ascertained on the Pakhuis Pass, at Bosch Kloof, and on Klein Vley, while a considerable thickness of the upper sandstones overlies the shale band at all the localities. The reappearance of the conglomerate on the downthrow side of the Augsburg fault most decidedly confirms the conclusion that the rock belongs to the Table Mountain series.

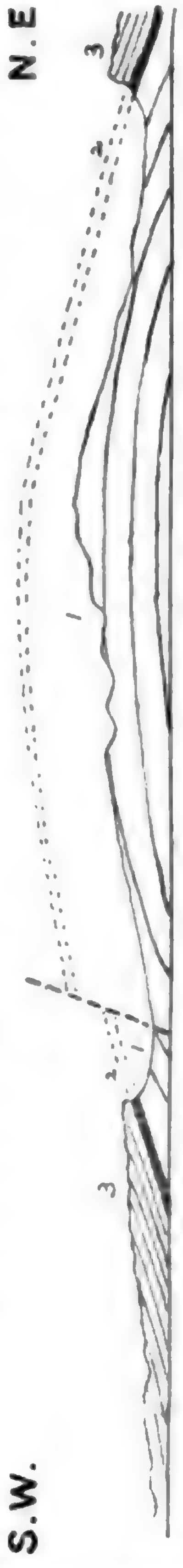

FIG. 2.—Section across the Cederberg Anticline and the Augsburg Fault.

3. Upper sandstones
2. Shale band } Table Mountain Series.
1. Lower sandstones

Vertical scale, $\frac{1}{10}$ in. to 650 ft. Horizontal distance, 13 miles.

Though there is a certain resemblance between the Pakhuis and Dwyka conglomerates there are important points of difference. The Dwyka conglomerate is remarkable amongst other things for being so constant in colour and appearance throughout a great region, with one general distinction between the northern and southern outcrops, due to the greater amount of alteration induced by earth-movements in the south. Now the Pakhuis conglomerate varies considerably even within the short range of twenty-three miles through which it has been traced. The red rock at the base of the Klein Vley outlier has no counterpart in the Dwyka conglomerate.

The variety of rocks occurring as boulders and pebbles in the Pakhuis conglomerate is considerably less than in the Dwyka, and quartz, quartzites and sandstones are more abundant in proportion to rocks of igneous origin in the former than in the latter. There is one peculiarity, in addition to the glacial striations, common to the boulders of the two conglomerates: many of them are traversed by several parallel planes along which they break easily,* and those planes are independent of the original structural planes of the rocks from which the boulders were derived. In each of the outcrops of the Pakhuis conglomerate these jointed pebbles can be found, and it was noticeable that the elongated pebbles were more frequently jointed than those of a roughly spherical form, and that the joints traversed the pebbles approximately at right angles to their longer axes in whatever positions the pebbles lay in the matrix.

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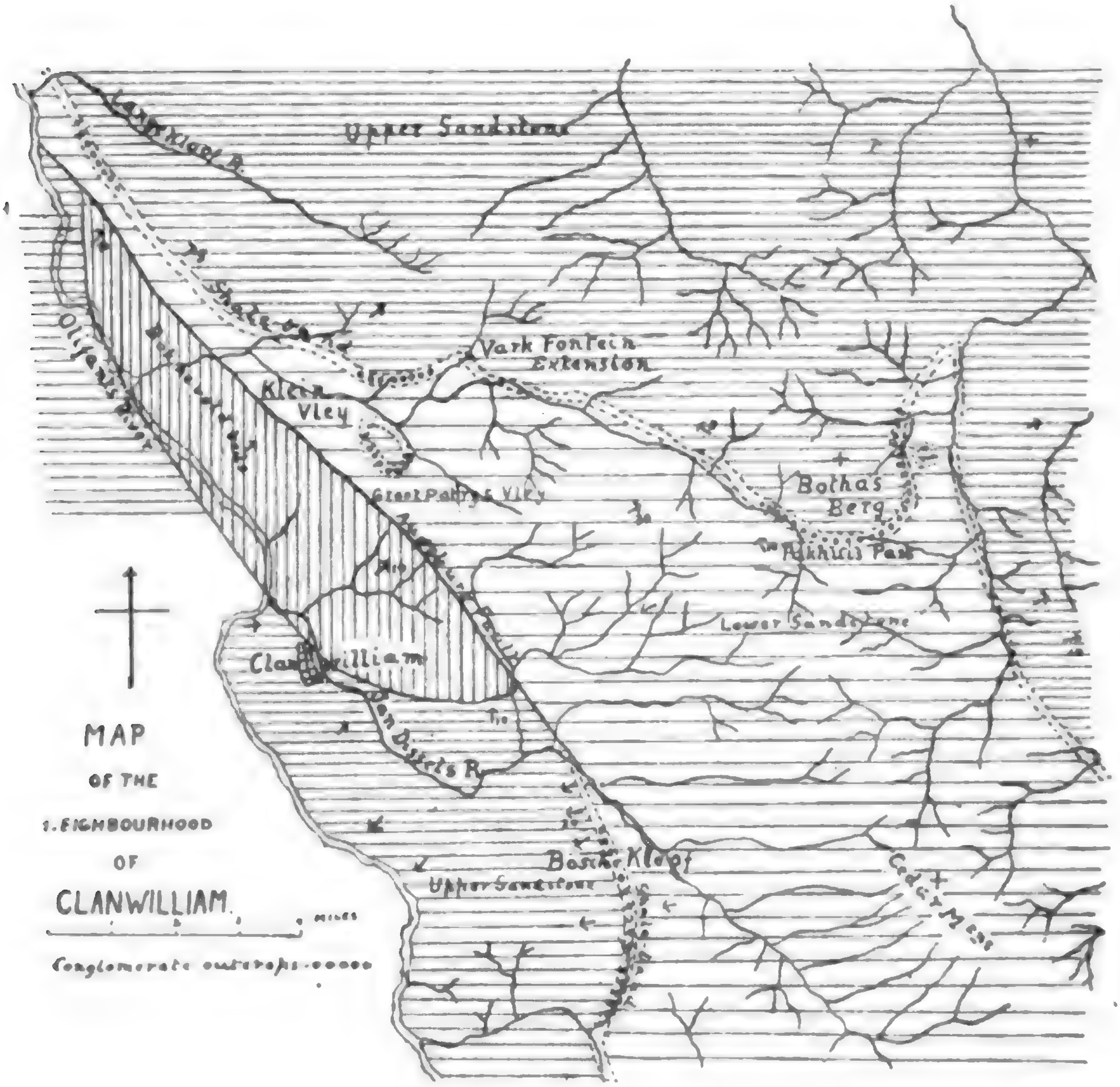
* See Schwarz, Trans. Phil. Soc., vol. xiv., p. 385, 1903. A figure of a jointed boulder from the Dwyka conglomerate of Prieska is given there.

In order to get some idea as to the conditions that prevailed during the formation of the Pakhuis conglomerate we must briefly recall the nature and distribution of the group of which it forms quite a subordinate part. The Table Mountain series consists chiefly of rather coarse sandstone, usually strongly false-bedded, and it contains many isolated water-worn pebbles of quartz distributed irregularly through the greater part of the sandstone. Occasionally, the pebbles occur together in layers one pebble thick; much more rarely they are sufficiently abundant to warrant the rock being called a conglomerate; in such cases, as at Pikenier's Kloof, Baboon Point, and a few other places in the Western districts, slates, sandstones, granite, and jasper are met with in the form of pebbles in addition to the usual vein-quartz. Argillaceous beds form but a very small proportion of the whole series: there is one group of them near the top, the shale-band to which the Pakhuis conglomerate belongs, and which has been followed through a distance of some 300 miles round the Colony, and there are irregularly-developed bands of red shale near the base of the formation. The whole thickness of the series is about 5,000 feet, of which probably not more than a twelfth is noticeably argillaceous. Current-bedding and ripple-marks can generally be found throughout the group, and sun-cracked surfaces have been seen in some of the red shaly beds near the base, so it is evident that the formation was deposited in shallow water, and at places parts of the area were laid bare for a short time before fresh sediment buried the dry surface of previously deposited mud. Although the whole region occupied by the formation between the Bokkeveld Mountain in Calvinia and the Umtamvuna river, where it passes into Natal, has not been carefully examined, the above description probably applies everywhere within those limits. The area in which the formation can be seen, or can be legitimately assumed to exist under the present surface, is at least 80,000 square miles in extent. No organic remains, except some obscure tracks or worm-castings, have as yet been found in the series; and the rocks are now sufficiently well known to allow one to hold that there are no important bands containing marine fossils. These facts most certainly negative the idea that the Table Mountain series was laid down under the sea, and it is difficult to reconcile the supposition of a lacustrine origin with the wide distribution of so much coarse sand, for in the tranquil water of a lake the coarse material brought into it by rivers is not spread over the whole area but is dropped near the mouths of the streams. It is probable that the series was deposited by a river or several rivers running over a slowly subsiding area. On this supposition alone we get over the difficulty of the preponderance of coarse sediment, its great thickness, the occasional layers of pebbles, and the general absence of the fine-grained material which must have been produced by the denudation of the ancient land from which all the sand came. The fine mud must have been carried away and deposited beyond the area we have access to. As to the sources of the deposits it is unsafe to speculate, but there are good grounds for the belief that the northern part of Cape Colony was a contributor.

It is a well-known fact that great thicknesses of gravels, sands, and fine dust accumulate in desert regions, but the Table Mountain series does not agree in many points with desert formations. To take one important point, there are no deposits of soluble salts, such as gypsum and rock salt, within the group, nor have any pseudomorphs or casts of crystals of these substances been found in it. The presence of such deposits is characteristic of deserts, and their formation on a greater or smaller scale, dependent on the extent to which drainage facilities are wanting, is one of the necessary results of the conditions which give rise to desert regions.

Though fluviatile conditions will account for the bulk of the formation, the wide distribution of the shale band averaging two hundred feet in thickness in the upper part of the series points to a change of circumstances of considerable duration; an increased rate of depression of the area, by which it was removed from the limits of deposition of coarse material, and converted into a lake, may have brought about this change. It was in this lake that the mudstone forming the matrix of the Pakhuis conglomerate was deposited, and into it were dropped by floating ice the finely-striated boulders shaped by glacial action. From the absence of angular fragments freshly derived from the parent rock mass, we may suppose that the boulders were carried to the places where they are now found from a considerable distance; they were probably derived not from the immediate shores of the lake but from the country behind, by the combined agencies of glaciers, streams, and floating ice. The area over which the glacial conglomerate has been observed—less than one hundred square miles are included within the lines connecting the outcrops furthest removed from each other—is so minute compared with the whole extent of the formation, that it is as yet impossible to know how far the glacial conditions affected the whole area, but it is to be expected that the conglomerate, or at least isolated glaciated pebbles are to be found far outside their range as known at present.

The striated stones have only been found in the lower hundred and twenty feet of the shale band, and below their upper limit the mudstone becomes bedded, and finally a thinly-laminated shale. Above the shale band the uppermost thousand feet or so of the formation seem to differ in no way from the sandstones below the shale band, so the fluviatile conditions returned and were maintained for a long period before the sea encroached upon the area and the Bokkeveld beds with their marine fossils began to be laid down.


Upper Sandstone
Vark Fontein
Extension
Klein
Vley
Olifants R.
Bothas
Berg
Pakhuis Pass
Lower Sandstone
Clanwilliam
Jan Dissels R.
Bosch Kloof
Upper Sandstone
Cedar Mts
MAP
OF THE
NEIGHBOURHOOD
OF
CLANWILLIAM
Miles
Conglomerate outcrops

THE ROCKS OF TRISTAN D'ACUNHA, BROUGHT BACK BY H.M.S. *ODIN*, 1904, WITH THEIR BEARING ON THE QUESTION OF THE PERMANENCE OF OCEAN BASINS.

By E. H. L. Schwarz, A.R.C.S., F.G.S.

(Read October 26, 1904.)

Introduction—Description of the Tristan d'Acunha group:—Tristan d'Acunha, Inaccessible Island, Nightingale Island, Stoltenkoff Island, Middle Island—Source of the specimens described—The importance of the study of Oceanic Islands—Does the level of the sea rise or the land sink?—The Agulhas Bank and Continental shelfs—Other Oceanic Islands, Atlantic:—Falkland Islands—The land connection between Africa and South America:—In Devonian Times, In Jurassic Times, In Later Times—The revelations of the pendulum—Other Oceanic Islands, Atlantic:—St. Paul's Rocks, Ascension, Mayo, Cape Verde Islands, Canary Islands, Gaussberg, South Georgia, Rockall Island, The Antilles—Legendary Islands:—Atlantis, Antilla, Brasil, St. Brandan's Island—Other Oceanic Islands, Pacific:—New Caledonia, Fiji Islands, Solomon Islands, New Hebrides, Tonga or Friendly Archipelago—Non-volcanic material brought up in volcanic eruptions:—Italy, Germany, Scotland, South Africa—The heat of volcanic eruptions:—Luzi's experiments in diamonds, Chaper's views on the South African diamond mines—Quartz sand in mid-Atlantic probably due to a cold volcanic eruption:—Sir A. Geikie's evidence from Scotland, Branco's evidence from Swabia—The heat of volcanic eruptions:—Kimberlite in Borneo, Australia, and Sutherland, Cape Colony, Agglomerate necks in the Drakensberg—The Cave Sandstone:—The Cave Sandstone, a variety of tuff, Similar rocks in Ascension, Peperino the same kind of material as the Cave Sandstone, The Cave Sandstone poured out as a mud, The Tonga tuffs—Review of the evidence in favour of volcanic islands standing on a continental base—Volcanoes not confined to ejecting molten material—The South African evidence for the theory that volcanoes are due to crustal friction:—The Bushveld amygdaloid, The Baviaan's Kloof crush-breccia, The Drakensberg volcanoes, The Sutherland volcanoes—The Sutherland and Griqualand West volcanoes:—The sinking of the Karroo basin, The intrusion of the dolerite, The effect of the heated material on the sedimentary rocks, The formation of the folded mountain ranges in the south of the Cape Colony, The production of shearing in the north of the Cape Colony, The volcanic pipes due to the heat produced by the shearing motion—Tristan d'Acunha rocks show the nature of the underlying ridge to be continental—The evidence of the South

African volcanoes—The connection of volcanoes with structural lines—The fusion of sedimentary rocks and the older crystalline series to form lavas—The nature of the earth's centre—The nature of the earth's original crust—Professor Vogt's researches in acid and basic types of rock representing rocks of the original crust—The magmatic separation of rocks into acid and basic series not due to gravitation—Conclusion—Petrography of rock specimens from Tristan d'Acunha, Inaccessible Island, and Nightingale Island.

Recently, when the annual vessel went down with mails for Tristan d'Acunha, I applied, through the courtesy of Sir David Gill, to the Admiralty at Simon's Town, to be allowed a passage on H.M.S. *Odin.* I was, unfortunately, unable to obtain the required permission, but I received a certain number of rock specimens which were collected by Commander H. L. D. Pearce, of H.M.S. *Odin*, Mr. Hammond Tooke, and Mr. Bonhomie, of the South African Museum.

When I was agitating about the matter, I was frequently asked, "What is the good of going there? The islands are purely volcanic, and there was not likely to be anything of geological interest there, except what has been recorded again and again in such islands." I could only reply I was unable to say what I could find till I had actually been there, and the specimens brought back show how much there is to be done there. I will endeavour in the present paper, in the light of the evidence from the specimens brought back, to show in what direction research must be carried on.

The specimens come mostly from Tristan d'Acunha, but there are some from Nightingale Island and from Inaccessible Island.

The Tristan group lies 1,550 miles from the Cape of Good Hope, 2,000 miles from Cape Horn, and 1,320 miles from St. Helena. The history of the group is given in the first volume of the "Narrative of the Voyage of the *Challenger*." The officers of that ship also collected specimens from Tristan d'Acunha and the other two main islands, and the following description of the localities from which theirs were obtained will hold good for the ones which are now deposited in the South African Museum. The *Challenger* specimens from Tristan consisted of large grained felspathic basalts, sometimes bordered with layers of black basaltic glass passing to palagonite, basaltic tuffs, augite andesite, pyroxenite, and amphibolitic andesite containing sanidine. Streams, or rather cascades, which come dashing down to the sea during the constant heavy rains, have eaten their way into the cliffs, and the beds form conspicuous features in the view as narrow gullies descending the rocks in a series of irregular steps. At the foot of the cliffs, immediately opposite the anchorage, there are débris slopes and irregular rocky and sandy ground, forming a narrow strip of low shore land. The settlement, called Edinburgh, lies on a broader and more even stretch of low land which extends westwards. At the margin of the lower tract a small low secondary cliff has been formed by the waves. Steep slopes of débris lead to the settlement from the cliffs, here and there broken into ledges and deep gullies by which ascent to the summit is made easy. At the landing-place the beach is formed of black volcanic sand, but elsewhere in the neighbourhood of coarse basaltic boulders.

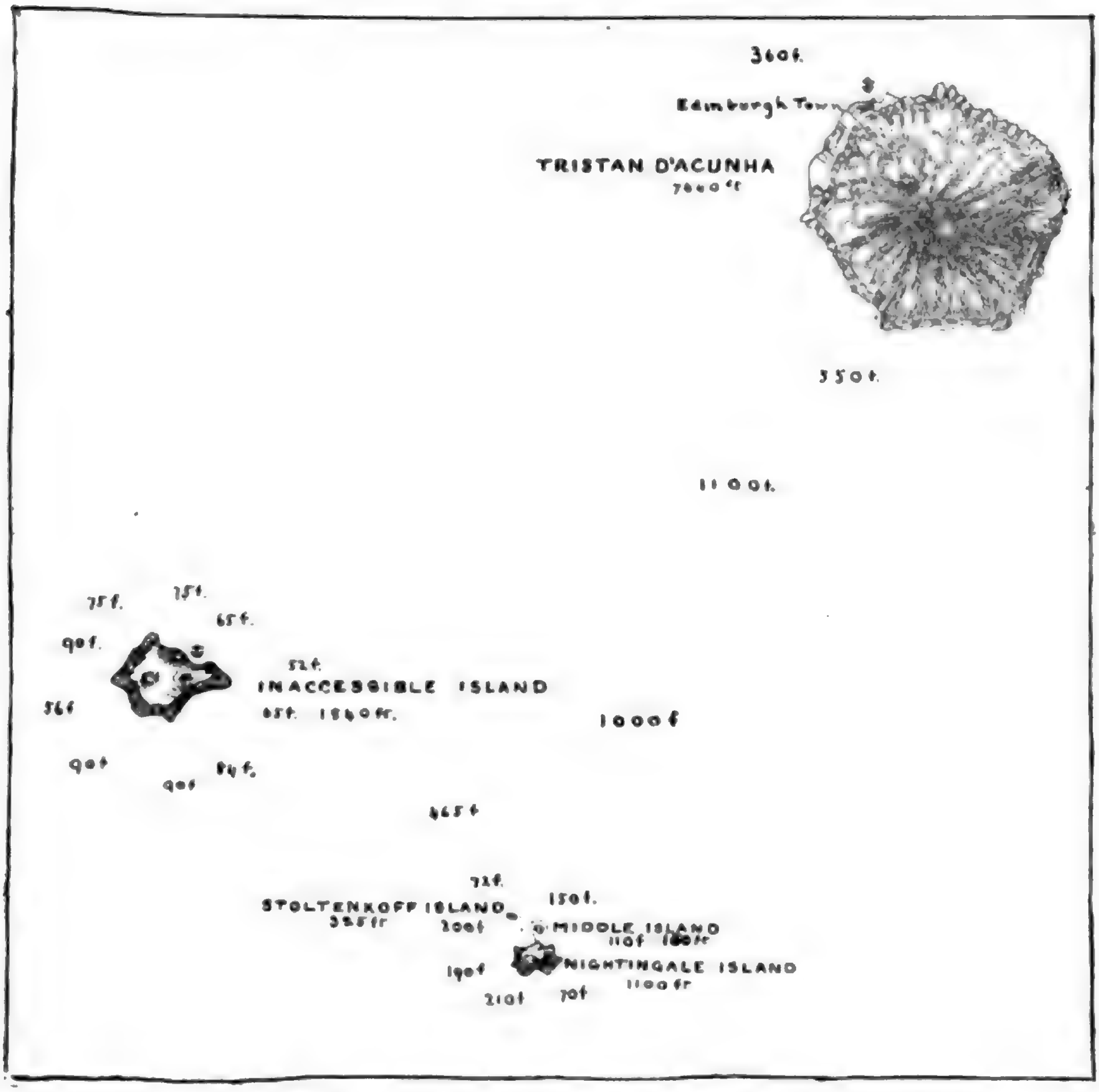

360f.
Edinburgh Town
TRISTAN D'ACUNHA
7640 ft
350f.
1100f.
75f.
75f.
65f.
90f.
52f.
INACCESSIBLE ISLAND
56f
65f. 1840 ft.
1000f
90f
90f
84f.
465f
72f.
150f.
STOLTENKOFF ISLAND
325 ft
200f
MIDDLE ISLAND
110f 160 ft
190f
NIGHTINGALE ISLAND
1100 ft
210f
70f

FIG. 1.—Plan of the Tristan d'Acunha group.
The position of Herald Point in Tristan d'Acunha is lat. 37° 2′ 45″ S., long, 12° 18′ 20″ W.

The perpendicular rocks that encircle the island attain a height of 1,000 to 2,000 feet, and form a terrace or plateau on which stands a conical peak, reminding one of the Peak of Tenerife; its summit, covered with snow for nearly the whole year, attains a height of

7,640 feet. The peak is a cone of black and red scoriæ, with a crater lake on the top; the diameter of the crater is about a quarter of a mile. From the coast other eminences of less height are visible on the plateau that forms the centre of the island. These hills are very probably also secondary cones of eruption; several of them, like the central peak, have crater lakes.

The cliffs are formed of nearly horizontal beds of basalt, alternately compact and scoriaceous, with intercalated layers of reddish volcanic tuffs. The whole system of beds slopes slightly towards the shore, as can be seen to the east and west of the harbour. These beds are traversed by dykes, generally vertical and of no great thickness. Torrents and atmospheric erosion have worn gullies in these walls of rock, and heaped together piles of débris, which have accumulated to a height of 100 feet at the foot of the cliffs. This circle of volcanic fragments is, in turn, edged by a belt of gravel of the same nature, which is spread out on the narrow shore of the island.

For nine months of the year terrible tempests run riot on the island, and when the season of rains has ended, and the snow that has accumulated on the top of the peak begins to melt, the water rushes down in cascades carrying an immense quantity of débris. These streams vigorously attack and demolish the less coherent and homogeneous of the layers that form the horizontal strata; they lay bare the rocks of the dykes, and cut deep indentations in the ledge of the terrace. The transverse dykes alone resist the erosion and stand up like walls.

The rocks were found by Mr. Buchanan to consist of basaltic lavas containing porphyritic crystals of augite, plagioclase, mica, titanic or magnetic iron, and in certain cases olivine. The groundmass was found to consist of microliths of the same species, especially augite and felspar; between these small crystals lay a vitreous base which plays a wholly subordinate part. At certain points a yellowish limonitic matter has been deposited as concretionary masses in the pores.

Above the basalt comes tuffs, the transition being effected through rocks that are richer in glassy materials, but belong, nevertheless, to the same lithological type.

The tuffs covering the sheets are formed of fragments in which the vitreous element predominates; they appear, under the microscope, to consist of a vesicular yellowish or brownish glass, passing occasionally into the hydrated, reddish, resinoid product of decomposition of certain basic volcanic glasses. The crystals that separate out from these vitreous fragments belong chiefly to greenish pleochroic augite, and are generally irregular in contour. The preparations show, besides, sections of the same mineral, and of plagioclase of smaller size, with clean-cut outlines, embedded in the glassy matrix, and belonging to a secondary period of consideration.

This tuff is overlain in turn by a rock of the same kind, but of coarser grain. It consists of lapilli 2 to 3 centimetres in diameter, and full of augite crystals visible to the naked eye. There also occur in it fragmentary crystals of olivine, which show their clastic origin very clearly under the microscope. The augite of the tuffs has a great tendency to form twin-crystals, as polysynthetic as those of some plagioclases. The crystals of plagioclase, augite, olivine, and magnetite are often of somewhat large dimensions; those of augite and plagioclase are corroded, and show the action of the base which surrounds them.

Hornblende occurred only in one of the *Challenger* rocks, but the specimen differed in no way from the other lavas except in the presence of this one mineral.

The dykes are very similar in composition. The minerals of the first generation are magnetite, olivine, and plagioclase. The last-named crystals are lamellar, and approach labradorite in composition. The ground mass of the rock is almost entirely composed of augitic microliths, which are grouped in rosettes or twinned crosswise, and sometimes planted almost perpendicularly on the plagioclastic lamellæ, or between the small prisms of augite, forming a fibro-radiating aggregate. Crystals of olivine with hexagonal or rhombic contours are frequent, enclosing a nucleus of glassy substance. Magnetite fills up the interstices between the various minerals that constitute the matrix in the form of irregular grains.*

Inaccessible Island, from which some of our specimens come, is very similar, and Sir Wyville Thomson was so struck with the general resemblance in the physical geography of Tristan and Inaccessible, that he thought that these two eruptive masses, now separated by twenty miles of water, had once been united.

The island lies to the west of the other islands, and is a little smaller than Tristan, from the summit of which its centre is about twenty-three miles distant. Abrupt cliffs, fringed with a line of breakers girdling the island, appear at first sight to make landing impossible, but there is a narrow beach at the base of the vertical rocks. Inaccessible Island is nearly quadrilateral in outline, the angles being directed towards the cardinal points. The highest part of the island is towards the west, where the cliffs rise to the height of 1,840 feet above the sea-level, the average elevation of the rocky wall being about 1,100 feet. A crag, 1,140 feet high, occupies the southern angle, and a conical mound of 700 feet rises in the south-west, the two heights being separated by a V-shaped ravine.

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* A. Renard, Phys. Chem. *Chall.* Exp. pt. vii.—1889, section vi. p. 74.

Nightingale Island is the smallest of the Tristan d'Acunha group, lying towards the south. It is surrounded by rocks, amongst which there are two islets measuring one-half by one-sixth of a mile. One of these, Middle Island, is 150 feet high, with an undulating summit. The second islet, which also lies to the north of Nightingale, is Stoltenkoff Island, and has a height of 325 feet. Nightingale Island is a mile long from east to west, and about three-quarters of a mile broad. A channel, ten miles wide, and over 465 fathoms deep, separates Nightingale from Inaccessible, while depths beyond 1,000 fathoms occur in some places between Nightingale and Tristan d'Acunha.

Nightingale differs greatly in appearance from the other islands of the group, being more varied in outline and surrounded by cliffs only thirty or forty feet high, and often less. The southern part of the island is more picturesque, the ground rising by successive crests to a peak 1,105 feet high, one side of which is almost vertical for half its height. The rest of Nightingale is undulating, and the rocks, except at a few isolated points, are covered with verdure.

No traces of recent volcanic activity are to be seen. The rocks consist chiefly of a conglomerate or breccia of doleritic fragments embedded in a whitish felspathic mass. Here and there the conglomerate is surrounded by beds of volcanic rock probably of more ancient origin. Marine erosion has hollowed the cliffs girdling the island into innumerable caves, which are situated a little above sea-level, and prove that the island has been recently elevated. A raised beach on the top of the cliffs confirms this supposition.*

The volcanic conglomerate is a phonolitic tuff. The bluish grey rock is speckled with white kaolinised patches; the ground mass is waxy and considerably altered, and is impregnated with limonite in some places. Under the microscope, the mass is composed of minute sections of nepheline, and in their arrangement show a well-marked fluidal structure. Microliths of augite are associated with the nepheline; sanidine, plagioclase, and hornblende are also present.

In this phonolitic mass there are embedded heterogeneous clastic fragments, which prove the tufaceous origin of the rocks, forming almost the entire explored portion of the island.

Eruptive rocks of an andesitic type like those of Nightingale are also present, together with vesicular hornblende andesites.

What the heterogeneous rocks contained in the tuff are is not clearly stated, but they appear to be basaltic and andesitic rocks, such as we find in the Drakensberg tuff necks. In the South African Museum specimens there are fragments containing sphene.

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* Buchanan, Proc. Roy. Soc., vol. xxiv. p. 614.

Middle Island is also composed of a tufaceous mass, and these two islands, therefore, must be considered to be two great tuff necks, such as are found along the Firth of Forth in Scotland, in the Eiffel and Swabia in Germany, in Griqualand East and Griqualand West in Cape Colony, and at Bingara in Australia; but the extraordinary fact of such a plug projecting out of the sea from deep water has never been properly recognised. In the following pages we shall have a good deal to say about such agglomerate necks.

An examination of the present specimens can add to the above description the occurrence of gneiss in Tristan d'Acunha, and the inclusion of fragments of a sphene rock, possibly an andesite, in the rocks from Nightingale Island, the latter thus showing some similarity with the volcanic series of the Falkland Islands. Otherwise our collection—though much more restricted in number of specimens to the *Challenger* one—contains, with the exception of nepheline rocks, very much the same types. There are, however, many points exhibited in our specimens, such as the presence of sphene rocks, which urgently call for a proper investigation of this interesting group of volcanoes.

The gneiss block was picked up by Mr. Hammond Tooke near the settlement of Edinburgh. The finding of such a rock naturally excited our interest, and there was expressed considerable doubt as to whether the block had not been thrown out from a ship in ballast, or had floated thither by icebergs from the far south in ancient times, when possibly the island might have been lower, and the ice floated much further north than it now does. In the Nightingale rocks, however, there are fragments of a porphyritic rock imbedded in the lavas; these are minute fragments that have evidently been derived from the shattering of a foreign igneous mass of an acid type by explosions, such as occur in the throats of volcanoes, and thus cannot have been drifted to the island. While the evidence is not as good as one could wish for, and would not be admissible were the islands more easy of access, or had a geologist been to the place himself, nevertheless, it is reasonable to suppose that the granite belongs to the islands, and has been actually spouted out of the throat of the volcanoes in the same way as the granite and gneiss in the Island of Ascension, a similar volcanic island in mid-ocean.

A petrological description of the rocks follows at the end of the paper. I propose first to discuss the bearing of these new finds of rocks of a continental type on islands separated by so many hundreds of miles from the mainland, and surrounded by water of almost abysmal depth. Incidentally, also, I shall raise the question of the origin of volcanoes, and shall adopt Dr. Sterry Hunt's theory that lavas are re-melted portions of the already solidified crust and even of the older sedimentaries, and that the force that gave rise to the heat was crustal movements producing friction, thus reviving the theory of Mr. Mallet, which, though universally held to be a brilliant one, has been rejected on grounds which do not appear to be sufficient.

The question of oceanic islands is one of paramount importance in the understanding of the form and figure of the globe, apart from its purely geological interest. For it has been found in the measurement of the force of gravity at various places by means of the pendulum, that the value calculated by using any one of the estimates of the true form of the globe is too great in oceanic islands and too little on the coasts of the continents; that is to say, the level of the sea at places in mid-ocean is too low, and on the coasts too high, if the curvature of the surface of the sea corresponded to its mathematical value. The waters were said to heap up round the continents and sink in a basin-form in the middle. This was explained by the attraction of the mass of the continents on the water.[*] Fisher,[†] however, has shown that there is another possible explanation, namely, that the average density of the rocks forming the continent might be less than that forming oceanic islands, and, indeed, the floor of the ocean as well. For supposing the theory of Isostacy to be true, then the continents projecting so high above the sea would have to have a very large base of material of low specific gravity dipping into the rock-mass of the earth's crust in order to float them, on the principle of an iceberg floating in water. As the average specific gravity of continental types of rock is 2·68, and that of the basalts and andesites, of which oceanic islands were once universally thought to consist of, is 2·96, the attraction of so great a column of heavy material would affect the pendulum sufficiently to let it swing the extra two or three times in the day, when placed on an island in mid-ocean where the heavier rock was supposed to extend downwards to the region of perpetual fusion.

The presence of granite in islands so characteristically oceanic as the Tristan d'Acunha group is subversive of all that we have so confidently asserted in the past. Oceanic islands are purely volcanic, say the text-books, and they then give a list of exceptions. First and foremost are the Seychelles with a great variety of rock types that are the same as those found on the mainland of Africa.[*] The explanation of this is fairly satisfactory, for it is very nearly certain that in former ages there was a great extension of the Madagascar ridge, probably assuming continental proportions, and this has now by earth movements been dropped, and only the highest portions left above sea-level.[†]

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[*] Suess, "Autlitz der Erde," vol. i. p. 3.

[†] "Physics of the Earth's Crusts."

It is quite legitimate to question whether the sea has not risen instead of the land sinking, and as this is an important factor in the following discussion it is worth while stopping to examine the arguments for and against at this place.

The latest upholder of the rising of the sea in some instances, as against the sinking of the land, is Mr. Reade, who adduces in evidence the great extension of submarine plateaus that extend out from the continents. The most notable examples are those on either side of the North Atlantic. For some 150 miles off what is now land in Europe, the plateau extends, having an average depth of 100 fathoms; on it are the elevations called the Rockall Island and Bank,[‡] and the Porcupine Bank, the latter only rising to 85 fathoms; the one is 240 miles from the Irish mainland, the other 130 miles. Similarly off the American coast the shelf extends under the sea for a great number of miles, and includes the Newfoundland Bank. Professor Cole also seems to add confirmatory evidence from his quoting the evidence of Nansen, that between Iceland and Jan Magen Island there are sunken shell banks.[§] Mr. Reade would argue that it is improbable that two great land masses on either side of the globe would simultaneously sink to the same extent, and leave corresponding shelfs containing the land surface at approximately the same depth beneath the sea; more probably, he says, the sea-bottom was elevated, and the water overflowed the margin of its former basin.

In South Africa we have a similar shelf projecting into the sea, whose edge is known as the Agulhas Bank; and the question has, therefore, interested me for a long time. It is certain that the volume of the ocean-basin can, and is, repeatedly altered by earth movements going on on the sea-floor, the very fact of islands suddenly appearing, such as those of Graham's Island, or Ile Julia, between Sicily and the coast of Africa; Sabrina Island off St.

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[*] E. P. Wright on the Seychelles Islands, Rep. Brit. Ass. 1868, p. 143.

[†] See "Volcanoes of Griqualand East," Trans. Phil. Soc., vol. xiv., Cape Town, 1903, p. 98.

[‡] J. W. Judd and T. Rupert Jones, Trans. Roy. Irish Acad., vol. xxxi., 1897, pp. 59 and 97.

[§] S. A. Cole and T. Crooke, Appendix No. IX. to Part II. of "Report on the Sea and Inland Fisheries of Ireland for the year 1901," p. 9 of author's reprint.

Michael's in the Azores; and the Falcon Island in the Tonga group; as well as the sand island in Walfisch Bay, so ably described by Mr. Waldron in the Transactions of this Society, is clear enough evidence. The volume of the ocean is so immense, however, that the amount of contraction necessary to raise the surface level 100 fathoms, is beyond what we have observed to be the possibilities of earth-movements.

There seems to me to be a very simple explanation of the continental shelf, if we assume the correctness of the principle of isostatic equilibrium, that is, that if the crust of the earth be weighted with sediment at one place and relieved of a load at another by denudation, there will be a sinking at the former and a rising of the latter. Applying this to the case in question, the interior of the continent being rapidly eroded and washed away, and the materials that once went to form the mountains are being deposited off the shore as sediment, there will, therefore, be a tilting seawards, the coastal regions will be submerged while the interior will rise. This is no new idea that is unsupported by any clearer evidence than what I have just given; it can be actually seen in progress in South America where the tilting of the continent towards the west was recognised when the first account of its geology was brought home by Charles Darwin.

Other examples of oceanic islands containing continental types of rock are those of the Falkland Islands, South Georgia, and Trinidad, but these, as clearly as the Porcupine Bank and the Rockall Island, are situated on the continental plateau, and their geology, therefore, excited no great attention.

The Falkland Islands are especially interesting. They contain volcanic rocks surprisingly like those of Tristan d'Acunha and our Cave Sandstone; primarily, however, they are made of rocks which appear to belong to the same series as our South African Witteberg and Bokkweld beds; at any rate, the fossils that have been brought from there are such as might have been collected in the Colony—at Ceres, for instance. The type to which this fauna conforms to is decidedly unlike the European Devonian fauna; it is characterised by the Brachiopod, *Leptocoelia flabellites*, Conrad, the *Orthis palmata* of Morris and Sharpe, a form which, associated with *Vitulina pustulosa*, Hall, a number of Spirifers, Conularias and Trilobites of peculiar species, is found throughout North and South America in certain zones of the Devonian.* We thus get an assemblage of

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* Conrad, 5th Ann. Rep. N.Y. Geol. Survey, 1841, p. 55; Morris and Sharpe, Q.J.G.S., II., 1846, p. 276; Hall, Palæont. N.Y., 1859, vol. iii. p. 449 Billings, Geol. Canada, 1863, p. 369; Meek and Worthen, Geol. Surv. Illinois, III.,

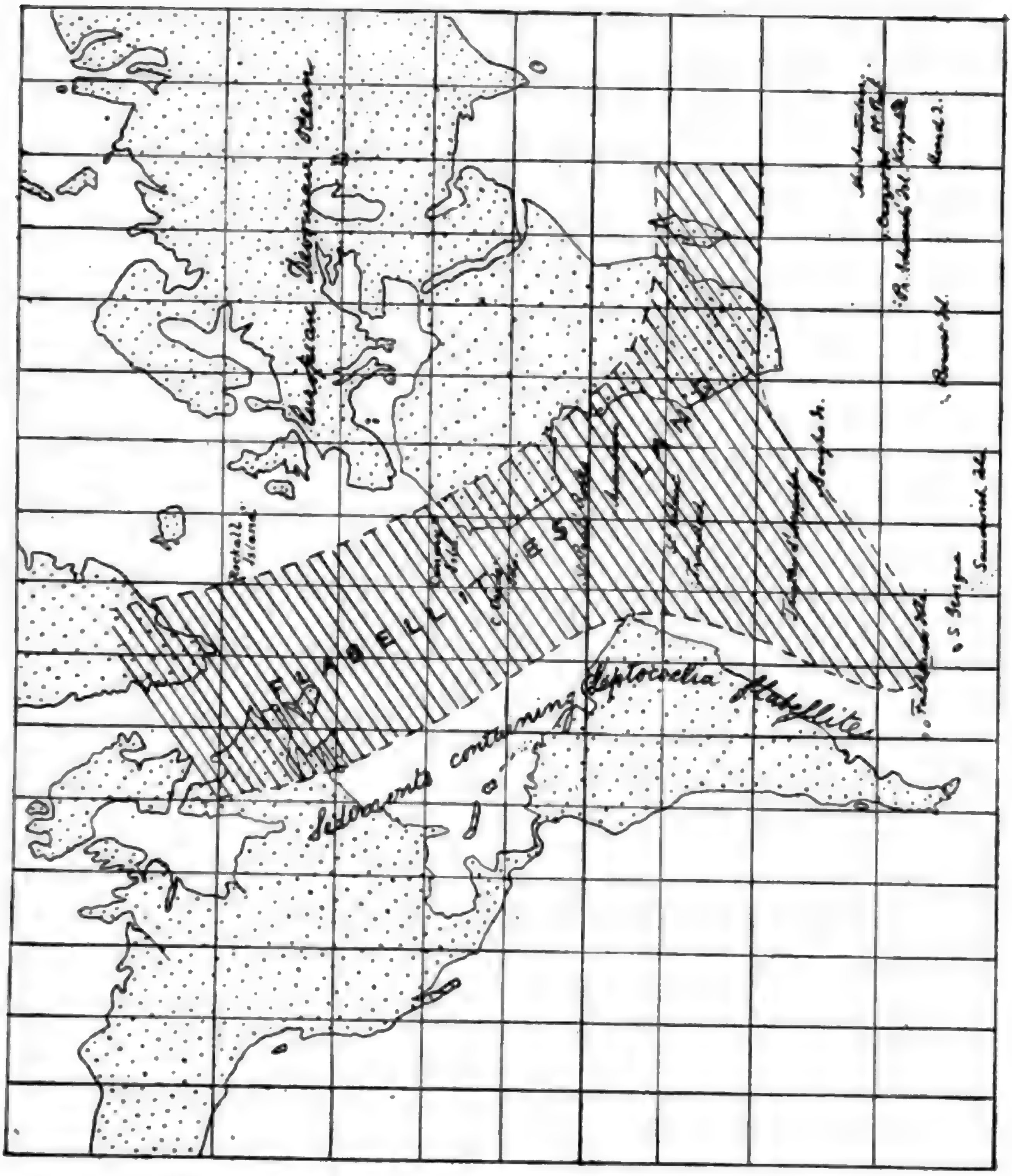
European Devonian Ocean
Rockall Island
FLABELLITES LAND
Sediments containing Leptocoelia flabellites
Gough I.
Bouvet Id.
S. Georgia
Sandwich Id.
Falkland Id.

FIG. 2.—MAP. MERCATOR'S PROJECTION.

Showing the probable extension of the land from which the sediments containing *Leptocoelia flabellites* were derived. It thus formed a bar between the north-eastern and western and southern oceans in Devonian times.

animals that are found in the rocks extending over a great area from North America to the south of the Cape Colony, with a heel projecting southwards to the Falkland Islands. That this fauna is so strikingly different from other contemporary faunas is an argument in favour of a former continuity in the land masses which yielded the materials of the sediments in which the animals are now imbedded.

Neumayr * inferred a land connection between Africa and South America in Jurassic and Lower Cretaceous periods from the following evidence:—(1) The absence of Jurassic marine beds on the western coast of Africa and on the eastern coast of South America; (2) the evidence of ancient land in the Cape Verde Islands and St. Paul's; (3) the fact that the Neocomian (Wealden) Uitenhage fauna of the Cape Colony differs entirely from the European, whilst the Jurassic fauna of western South America does not.

Dr. Blanford states † that the biological evidence of a former land connection between South America and Africa is much stronger than that in favour of a belt of land between Africa, Madagascar, and India, although the latter is supported by geological data. He gives among other evidence the presence of fresh-water fishes of the important families, *Chromididæ* and *Characinidæ*, which are almost entirely confined to these two continents, and the Dipnoans, *Lepidosiren* and *Protopterus*, the one South American, the other African, being the only representatives of the group. Very striking, also, is the distribution of the Amphisbænidæ, the two genera *Amphisbæna* and *Anops* being represented in both the southern continents bordering the Atlantic, while the genera in Northern Europe and North America are not nearly related. Dr. Blanford argues from the distribution of living animals that the land connection across the South Atlantic lasted to a later geological epoch than that across the Indian Ocean.

The evidence is very much in favour of this connection of Africa with South America, and is sufficiently strong to base further argument upon. It does not matter whether this connection really followed the great arc through the Trinidad group and just to the north of Tristan d'Acunha, and perhaps embracing the whole width

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1868, p. 397; Ulrich, "Neues Jahrbuch," Beil. Bd., VIII., 1893, p. 60; von Ammon, Zeitschr. Gesell. f. Erdkunde, Berlin, 1893, p. 363; Clarke, Archiv. Mus. Nac. Rio de Janeiro, X. 1899, p. 99; E. M. Kindle, 28th Ann. Rept. Geology of Indiana, 1904, pl. ii., fig. 6; Katzer, "Grundzuge der Geologie der unteren Amazons gebietes," Leipzig, 1903; Reed, Ann. S.A. Museum, IV., 1904, p. 192.

* Denkschr. K.K. Ak. Wiss. Wien, Math.-Nat. Cl., Bd. L., 1885, p. 132.

† Anniversary Address, Geol. Soc., London, 1890, p. 73.

of the space between this and the comparatively shoal water that runs through Fernanda Noronha and St. Paul's Rocks to the coast of Sierra Leone, as the evidence of the Devonian fossils seems to indicate, or whether it bent more to the south, following the line of the Falkland Islands, South Georgia, and the Sandwich group, then coming up through Bouvet Island to the Cape. In both directions it must have crossed some of the great depths of the ocean; the southern one would be more to the liking of those who still believe in the permanence of ocean basins, but a greater abyss would have to be crossed, whereas the more northerly alternative is still dotted with banks and shoals. The point I wish to bring out is that it is extremely probable that beneath the sea in the South Atlantic there is an old continent sunk beneath the waters, and containing all the various rocks such as granites, gneisses, old schists, and quartzites.

The mean excess of vibrations of the seconds pendulum on stations in oceanic islands is 5·26 vibrations a day; in the Falkland Islands, where the rocks are composed of the ordinary materials of continents, there is a defect of 3·85 vibrations, and this would seem to indicate clearly that there is some fundamental difference in the rocks underlying islands like the Falkland and Comoro Islands and the Seychelles, which contain continental materials, and those of purely volcanic origin.

In the "United States Coast and Geodetic Survey" there is an account of the measurement of gravity at the base of the volcano Fujisan in Japan. The cone is 12,000 feet high, which was said to have been thrown up in a single night in the year 300 B.C. The mountain was found to attract the pendulum exactly as a mass of the same size would do if it had been carted thither and piled up.* A truly oceanic island is just such a cone as Fujisan, only its base lies so many fathoms deep beneath the surface of the water, and it seems very probable that the mass of volcanic ejectamenta is sufficiently great, compared with the mass of the pendulum bob, to obscure any effects that might be caused by the density of the floor on which the lavas are piled up. I do not, therefore, think that the revelations of the pendulum need necessarily preclude the existence of an ocean floor made of the same materials as continents.

Sir John Murray, however, some years ago stated: "There has not been found in the abysmal areas any land made up of gneisses, schists, sandstones, or compact limestones; nor have fragments of these sedimentary formations been found in the erupted rocks of volcanic islands, though they are frequent in the volcanic eruptions of continental areas."[*] Darwin's observation of the serpentine on St. Paul's Rocks is taken to be a volcanic peridotite though Professor Renard states very strongly that the foliation of the mass, and the drawing out of the olivine crystals in the shape of a V, is evidence of mass deformation, such as takes place in schists, and is not such as results from the flowing of a liquid magnia, Professor Renard, however, was uncertain; his first letter to Professor Rosenbusch states that he was quite sure that the Serpentine, Peridotite, or Lherzolite—for the rock has been called all three names—was volcanic, a view that Professor Rosenbusch endorsed.[†] In the *Challenger* reports, however, he first states that it is volcanic; but adds in a footnote that he must express himself with more reserve "because recent researches tend more and more to establish the fact that in many cases peridotites are rocks embedded in the schisto-crystalline series, with which they must have a common origin."[‡] Neumayr states that St. Paul's Rocks lie on a line characterised by volcanic eruptions; this line includes St. Helena, Ascension, St. Paul's Rocks, and the area of frequent submarine volcanic action situated in long. 20–22° E. and lat. 0° 30′ S.[§]

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* "United States Coast and Geodetic Survey," appendix 22, p. 507, Washington, 1883; O. Fisher, "Physics of the Earth's Crust," 1889, p. 251.

Sir A. Geikie supported the volcanic origin of the rock,[‖] and Mr. M. E. Wadsworth attacked Professor Renard's interpretation of the microscopical evidence,[¶] and Professor Renard replied.[**] The outcome of the discussion is represented in Neumayr's acceptance of the non-volcanic origin of the rock,[††] though at the same time he recognises that it lies in a volcanic region.

While the evidence at St. Paul's Rocks is not quite satisfactory, that at Ascension is quite definite. Darwin states[‡‡] that, "In the neighbourhood of Green Mountain fragments of extraneous rocks are frequently met with embedded in the midst of scoriæ. They nearly all have a granitic structure, are brittle, harsh to touch, and apparently of altered colours. Darwin's principal finds were: *Firstly*, a white syenite streaked and mottled with red, consisting of well-crystallised felspar, numerous grains of quartz, and brilliant though small crystals of hornblende. *Secondly*, a brick-red mass

[*] Brit. Assoc., 1885, Aberdeen, *Nature*, vol. xxxii. p. 582.

[†] "Neues Jahrbuch," 1879.

[‡] *Challenger* Reports, "Petrology of St. Paul's Rocks," p. 15.

[§] Erdgeschichte, Leipzig, 1890, p. 199.

[‖] *Nature*, xxvii., 1882, p. 25.

[¶] *Science*, I., p. 590, 1883.

[**] Bul. Soc., "Belge de Microscopie," p. 165, 1883.

[††] Deukschr, k.k. Ak. Wiss. Wien. Math.-Nat. Cl., Bd. L., 1885, p. 132.

[‡‡] "Geological Observations on Volcanic Islands," 1851, p 40.

of felspar, quartz, and small dark patches of a decayed mineral, one particle of which, he was able to ascertain by its cleavage, to be hornblende. *Thirdly*, a mass of confusedly crystallised white felspar, with little nests of a dark-coloured mineral, often carious externally and rounded, having a glassy fracture, but no distinct cleavage; from comparison with the second specimen he had no doubt that it was fused hornblende. One other large fragment was a conglomerate, containing small fragments of granitic, cellular and jaspery rocks, and of hornstone porphyries embedded in a base of wacke, threaded with numerous layers of a concretionary pitchstone passing into sideromelan.

In the *Challenger* Reports there is confirmatory evidence of Darwin's observations; Professor Renard records from Ascension, amphibolic granite, granitite, diabase and gabbro, torn up from the depths by eruptions of basalt or trachyte.* Doelter, also, has recorded that in the island of Mayo, in the Cape Verde Islands, there occur the very rocks that Sir John Murray says are not to be found on oceanic islands, for instance, compact limestones and crystalline schists.† The *Challenger* specimens, however, do not confirm Doelter's observations. Gneiss also occurs in the Canary Islands.

In the far south there is another volcanic island, the Gaussberg, which is an isolated basalt cone rising from the sea at the edge of the inland ice of the Antarctic. There are no tuffs, but embedded in the lava there are large boulders of granite and gneiss. The dark constituents, biotite and probably hornblende, are altogether melted away, the lighter materials, quartz and felspar, are also affected and altered by heat but still remain *in situ.* Into the cavities which the melting of the dark minerals has left, the glassy lava has penetrated and occupies the original spaces of the crystals by a sort of pseudomorphism. Granite and gneiss boulders lay plentifully about the summit of the mountain, showing that the inland ice once covered it. It is hence not quite clear whether the blocks in the lava have been brought up from the throat of the volcano or are simply surface-blocks entangled in the molten mass; the intensity of the alteration by heat, however, suggests the former explanation.‡

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* Rept. Results *Challenger* Exped., "Physics and Chemistry," II., pt. vii. "Report on the Petrology of Oceanic Islands," p. 62.

† "Spuren eines alten Festlandes auf den Cape verdischen Inseln," Verh. k.k. Geol. Reichanstalt, Wien, 1881, p. 16.

‡ E. Philippi, "Veröffntlichungen des Inst. fur Meereskunde," Heft 5, 1903, p. 126.

The Island of South Georgia, separated from South America by 1,200 miles of deep ocean, is made of slates and crystalline schists. It is, therefore, said to be on the same continental ridge as the Falkland Islands; but as the soundings indicate that this submarine ridge is continued out towards the Sandwich Islands, it is highly probable that these also stand on a continental base.*

I have already referred to the Rockall Island, and have classed it as belonging to the continental shelf because it lies near the submerged plateau, that is to say, it can be regarded as an island off the submerged mainland. All the same, the channel separating it from the plateau round the British Isles runs to depths of 1,300 and 1,500 fathoms. Rockall Island lies 240 miles distant from the Irish coast, 290 miles away from the nearest point of Scotland, and 170 miles from St. Kilda; it is situated in lat. 57° 36′ N., long. 13° 42′ W. It is about 250 feet in circumference at its base and about 70 feet in height. At a radius of 2½ miles from the rock the depths are from 40 to 70 fathoms, but within this area two other small rocks rise nearly to the surface of the sea. "Haslewood Rock" is a small half-tide, detached rock, 1½ cables from Rockall, and "Helen's Reef" is 1¾ miles, and has about six feet of water upon it at low tide. Minute as it is in size, Rockall is exposed to the full swell of the Atlantic, which rises and falls here more than twelve feet in the calmest weather. The Rev. W. S. Green, of the Irish Fisheries Board, visited the spot in 1896, in SS. *Granuaile*, and got within 20 yards of the rocks. He describes the general character of the mass in the following words:—"The east face seemed like a great slab of grey granitoid rock with rectangular joints broken off at the north, so as to show the square edge of another slab, and this was in turn broken off, showing the face of a third. This granitoid mass rests on a rock showing a kind of bedding or jointing, dipping about east and at an angle of 30° or so." Three specimens of rocks from this place were submitted to Prof. Judd for determination, one collected in 1810 by Captain Basil Hall in H.M.S. *Endymion*, the others in 1862 by the officers of H.M.S. *Porcupine*. In each case the specimens were obtained by an active sailor, with a line attached to him, springing from a boat on to the rock, and, when he had secured fragments of it, throwing himself into the sea to be towed back to the boat.

Two of the specimens were distinctly granitic in structure, the quartz, felspar, and augite of which they are made being allotriomorphic, the other was more of the type of a dyke rock. Apatite needles are found enclosed in all the minerals of the rock, and among the secondary minerals, are magnetite quartz, arfedsonite, and a blue soda-amphibole.

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* Thurach, "Geognistische Beschreibung der Insel Sud Georgien, Ergeb. d. Deutsch," Polar Expedition, Allg. Theil, II. p. 7.

Prof. Cole, in describing specimens of boulders dredged off the Rockall Bank, states that they mostly consist of basalt, pumice, and scoriaceous andesite; one specimen, however, was a grey micaceous sandstone, another a red sandstone; nothing could be said respecting these, except that they resembled Torridonian and Ordovician rocks, so that the stratified beds on Rockall Island cannot yet be determined.* The point of greatest interest in the Rockall Island is that, although it is not truly an oceanic island, yet lying as it does so far from the mainland, it still contains rocks of the continental types, and one must suppose that similar ones are to be found under the sea beyond it.

In the West Indies we do not get truly oceanic islands, and yet in the smaller islands no rocks of a continental type have been recorded.† In nearly all the larger ones, however, crystalline, schists, sandstones, and shales are found. Trinidad is simply a prolongation of the continent, the channel which separates it from the mainland being only 36 feet deep, yet it is as certain as anything can be in a question of this sort that the same ridge that carries Trinidad, Puerto Rico, Haiti and Cuba, and comes up again at Yucatan on the one hand, and Florida on the other, is continuous throughout, and that the string of volcanic islands, forming the lesser Antilles, stands on a base made up of the ordinary types of continental rocks.

Before leaving the Atlantic, it is worth noting the persistency of the rumours as to land having once existed in mid-ocean. Plato called this land Atlantis; Aristotle, Antilla; while northern nations knew it under the name of Brasil. The extraordinary habit of lemmings in Norway and Sweden, at certain periods collecting together and making due west till they came to the sea, and, not stopped by this, of swimming, swimming ever westwards till they are all drowned, has been explained by supposing that at some distant date they used periodically to migrate to some land now submerged.

Off the Canaries, also, a mysterious island has been known in legend from the earliest times. Pero Diaz, a monk of the holy order of St. Francis, is said to have seen it in 1759, lying to the west, and having the appearance of the Blessed St. Anthony playing on a dulcimer; Fernando Correa, fisherman, who saw it at the same time, likened it to the head of a mule playing on a flute; while

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* Trans. Roy. Irish Acad., vol. xxxi, 1897, pt. 3, pp. 39–98; extract in *Geological Magazine*, Dec. iv., vol. vi. No. 418, p. 163, April, 1899.

† Spencer, West Indian Papers, Q.J.G.S., lviii., 1902.

Thomas Smith, Englishman, after a night of merry-making in the city of Santa Cruz, saw two islands.* It was known to the Portuguese as the island of Gomera, and is supposed to be that on which the Scotch abbot, St. Brandan, landed in the sixth century. There is, I think, no evidence to lead one to suppose that any of these legends had a basis in fact, or that during the last few thousand years this great mass of land, or even considerable islands, have disappeared beneath the Atlantic, although we have every reason to believe that such did actually take place in comparatively late geological ages.

Turning from the Atlantic to the Pacific, we find New Caledonia composed of ancient rocks, crystalline schists containing gold, coal beds, and, in fact, the usual assortment of varieties of rock that are found on the mainland of Australia. But New Caledonia, manifestly, lies on a submerged ridge connecting New Zealand with Australia and South-Eastern Asia.

In the Fiji Islands there exists quartzites and granites forming the base on which the volcanic superstructure is built. At Nasogo there is a tuffaceous conglomerate very similar to that at Ascension, containing well-worn pebbles of granite. But here there is an important addition: tertiary fossils occur embedded in the matrix. Besides granite, Woolnough records as having found *in situ* the following rocks: slates, quartzites, quartz-diorite, and old sedimentary rocks of an indeterminate age.† The Fiji Islands must, therefore, be classed among those standing on the same submerged ridge as New Caledonia and New Zealand.

From the same submerged ridge rise the islands, New Guinea, Borneo and Java, all with continental types of rocks.

The Solomon Islands contain extensive areas of quartzites and schists; a coarse hornblendic gneiss occurs at Thousand Ships Bay in Vulavu, crystalline limestone in Guadalcanar and Ysabel, and jasper in Guadalcanar and Vulavu. ‡

In the New Hebrides, gneiss and crystalline limestone occur at Malicolo and Espiritu Santo, and serpentine, like that at St. Paul's Rocks, at Aneityum. §

We have thus pushed the submarine plateau out from New Caledonia to the New Hebrides, from here to the truly oceanic islands constituting the Fiji group. These last rise from the 2,000 fathom-deep base. On the very edge of this same platform, and facing the abysmal depths of the Pacific, rise the Tonga or Friendly Archipelago, distant over 2,000 miles from the mainland of Australia. One of the group, named Eua, has yielded among the volcanic ejactamenta a boulder of uralitized gabbro, and in the tuffs, crystals of red garnet and tourmaline. Lester very rightly points out that these minerals indicate the near presence of crystalline schists.*

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* A. B. Ellis, "West African Islands," London, 1885.

† Woolnough, "The Continental Origin of Fiji;" Proc. Linn. Soc. N.S. Wales, 1903, pt. 3.

‡ Guppy, "The Solomon Islands, their Geology and General Features," London, 1887.

§ Imhaus, "Les Nouvelles Hebrides," Paris–Nancy, 1890, p. 122.

This observation raises a vast subject of inquiry, namely, the ability of volcanoes to bring specimens of the underlying rocks to the surface in the form of small fragments of dust and mud, and by the study of these to allow us to investigate the nature of the rock underlying the vent, much in the same way as when on a smaller scale, the geological surveyor utilises the burrows of rats and rabbits in a district covered with soil to see what solid rocks lie beneath.

From the earliest times it has been known that volcanoes tear off pieces of rock from the throat, deep down below the earth's surface, and eject them along with the lavas and ashes. As a rule, however, the general conception of volcanic activity is that of an outpouring of molten material, or of the ejection of this material which has been blown to powder by the explosive action of gases imprisoned in the liquid magma. It was this idea that obscured much of the earlier writings on volcanology, and still renders it difficult to get people to dissociate this idea of the effusion of liquid lava from the popular misconception of a liquid interior of the globe. The whole trend of recent work in this field is to prove that the interior of the earth is not liquid, and that a very large number of volcanoes eject solely and exclusively solid material, that is, rocks that have been torn from the throat of the volcano by the action of expansive gases, and which have not had time, or have not been subjected to sufficient heat, to get melted.

Such volcanoes have been found in the Eifel and Swabia, in Germany, and on the Firth of Forth in Scotland; but it must be remembered that even in the ordinary types of volcanoes in Italy that have been studied from the earliest times, granite and gneiss blocks, unmelted and unaltered, are occasionally brought to the surface in the eruptions.†

Unfortunately we have none of the cold volcanoes acting at the present moment, unless we except the Javanese and Andean mud-volcanoes. In South Africa the type has long been known to be represented by the Kimberley pipes, where the throat of the volcano is plugged with a breccia, or hardened mud, in which a great variety of rocks, granites, gneisses, mica-schists, slates, &c., besides the basic eclogites, and even tree-trunks are found.

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* J. J. Lester, Q.J.G.S., 1891, p. 600.

† Branco, "Swabiens Vulcan Embryonen," Stuttgart, 1894, p. 760.

The last named show clearly enough the small heat that must have existed during the expulsion of the breccia mud, but it might be argued that the trees only fell down into the mass after it had cooled. Against this, however, we have the conclusive experiments of Luzi who embedded diamonds in the Kimberlite matrix which he kept heated to 1,770° C. for half an hour. On cooling the mass and taking out the diamonds,* he found these intensely corroded, showing that the diamonds could not have been swirled about in the magma in which they now are found, and which was once molten, but must have got into their present position while the breccia mud was comparatively cold. The slight amount of corrosion exhibited in most Kimberley diamonds was no doubt caused by the action of the blue-ground; the original matrix, however, from which the diamonds crystallised was in all probability a metallic one, the amount of titaniferous iron ore in the blue, pointing to the original matrix having been an alloy of titanium and iron.†

Chaper was so impressed with the absence of heat in the Kimberley mines, the included blocks being unaffected, and the rocks forming the sides of the chimney showing no trace of metamorphic action, that he inclines to the view that the nearest analogues of the outbursts that formed the Kimberley vents are those that take place in petroleum regions. In the latter, through the action of carbonic acid gas, at low temperatures, there occur sudden bursts of mineral oil accompanied with sand, the latter representing, as it were, the serpentinous mud of the Kimberley breccia.‡

In mid-Atlantic the recent voyage of the German South Polar expedition in the SS. *Gauss* dredged quartz sand from the sea bottom in lat. 32° 52″ S. long. 13° 18′ E.; from a depth of 2,750 fathoms; the deposit has been described by Dr. Philippi.§ The sand was entirely outside the area to which land detritus could be brought, and the deposit was far too great to have been rubble brought there by some gigantic iceberg that had floated thither in olden days. Mellard Reade regards it as evidence of the far-reaching effect of sub-oceanic currents, but I think it is more likely to be a quiet volcanic eruption of the type Chaper refers to, and the quartz sand to be a part of the old sedimentary beds forming the ocean bed blown to fragments and strewn over the ocean floor.

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* Uber kunstliche corrosionsfiguren auf Diamanten, Berichte der deutsch. chem. Gesell., Jahrg. 25, No. 14, Berlin, 1892, p. 2470.

† See on this question, Moisson, "Comptes Rendus," cxvi., p. 292, 1893.

‡ Bull, Soc. Geol. France, 3 ème series, tom. 19, pp. 313 and 944; also, Note sur la region diamontifère de l'Afrique Australe, Paris, 1880, p. 42.

§ "First Fruits of the German Antarctic Expedition," *Nature*, 1902, p. 224.

Branco[*] has called attention to the fact that the inclusions in the tuff-necks in Swabia are only in rare cases affected by heat, and the same has been observed in the granite and gneiss blocks in the Weinfelder Maar in the Eifel, as described by von Dechen.[†] Sir A. Geikie[‡] in the rocks included in the necks along the Firth of Forth says the same thing; in one instance, in the vent at Elie Neck, he says:—"Among the non-volcanic contents of the agglomerate, special reference may be made to the numerous fragments of crinoidal limestone in certain layers. These show no trace of metamorphism, their crowded organisms being as clearly recognisable as in pieces of limestone from a quarry." In the Schleursbach volcano in Swabia, the marly middle Lias blocks, as well as the rock in the circumference of the pipe, are burnt black, while the included Belemnites are altered to white marble. Branco says the alteration has been caused by the heat of the tuff, and not by the action of hot gases, as Deffner[§] maintained, but this heat has been so little that the fossils have not been obliterated. Branco deplores that no diamonds have been found in the German pipes. None have been found in the Scotch ones.

In Borneo[||] diamonds occur in a peridotite like the Kimberley rock, but there is no mention of a pipe. In Australia, however, the Bingara pipe is in most respects similar to the South African diamond pipes, and diamonds have been found in it.[¶] The very large number of similar pipes that were found by Mr. Rogers in Sutherland,[**] leads one to suspect that the Indian and Brazilian diamonds may eventually be traced to a breccia neck like those in South Africa have been, and that new areas in which these cold volcanoes are found may be added to those already known.

It is interesting to note that one can trace a temperature gradation in these breccias from entirely cold ones like the rock in the Elie

[*] "Swabiens 125 Vulkan Embryonen," Stuttgart, 1894, p. 761.

[†] "Geogn. Führer zu der Vulkanriehe der Vordereifel," Bonn, 1861, p. 254.

[‡] Geology of Eastern Fife, Mem. Geol. Survey, Scotland, Glasgow, 1902, p. 241.

[§] "Swabiens Vulkan Embryonen," p. 546.

[||] Knop, Sep. Abdruk a.d. Bericht. 23 Versamml. des oberrhein geol. Vereins.

[¶] Stonier Occurrence of Diamonds at Bingara, Records Geol. Survey, N. S. Wales, 1894, vol. iv., pt. 2, p. 51; see also Card, ib., vol. vii., pt. 2, p. 29.

[**] Ann. Rept. Geol. Comm., 1903, Cape Town, 1904.

Neck, to ones which must have had a molten magma like the Nightingale agglomerate.

In the Drakensberg I found a great many of this kind of volcano, and also many filled in with a peculiar white chalky-looking sandstone. Just under the lavas which form the crest of the Drakensberg there is a thick bed of sandstone of precisely similar nature, called by Dunn the Cave Sandstone. One would at first be tempted to think that the explosion that caused the vent, burst through this sandstone, and the shattered remains then fell back and filled the pipe. Against this, however, we must remember that the Cave Sandstone is a comparatively thin band among a vast thickness of beds made up of other materials, and it is not probable that the rending of the outburst would affect this particular bed alone; if the Cave Sandstone was formed before the production of the material in the pipe, then the latter ought to be made up of portions of all the rocks which the vent traverses, but we find that this is not the case, and that the material in the pipe is identical with that of the Cave Sandstone. We must, therefore, suppose that the Cave Sandstone was produced as a tuff which was blown out of the vents, a portion of which still, in some cases, remains in the throat.

I was greatly puzzled about the nature of the Cave Sandstone; it was so strikingly different from ordinary sedimentary beds, and had the appearance of a trachytic tuff; as all the lavas, however, round about were of a decided basic type, I was at a loss to account for acid material. An analysis by Mr. J. Lewis gave 83·5 of silica. A microscopical examination showed besides the quartz grains, microcline and plagioclase felspar, zircon, rutile, tourmaline, chlorite, garnet, and epidote. The chalky look of the rock was produced by a growth of white alteration products round the quartz grains.* I was obliged, therefore, to consider the white rock plugging the vents as the triturated material torn off from the throat of the canal which must have gone so far below the present surface of the land that it tapped the deep-seated rocks underlying the newer sedimentaries. These old rocks crop out in Natal, and are composed of granite and crystalline schists, precisely the kind to yield the minerals found in the Cave Sandstone and its prolongations into the vents.

Had there been any land surface composed of granite and crystalline schists near at hand from which the materials could have been derived by the ordinary course of denudation, I might have hesitated on putting forward this view. As it is, there are undoubted sedimentary beds of the Molteno series underlying the Cave Sandstone, and the sandstones in them are composed of the detritus of a granitic region. The origin of this latter rock is to be sought for in the existence in those times of a prolongation of the Madagascar ridge southwards, till it touched the present eastern coast of the colony;[*] the material must have been derived from the south, for to the north hundreds of miles separate the Matatiele district from the granitic regions of the Transvaal, and the intervening rocks are all sedimentary, or, when igneous, of a basic type.

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* Ann. Rep. Geol. Comm., 1902, Cape Town, 1903.

The break in the deposition of the Molteno beds marked the disappearance of the source of supply; and the great difference between the nature of the glittering sandstones of the Molteno beds, which with all their high content of unaltered felspar, are interbedded in clays containing fossil forces, and are, therefore, truly sedimentary, with the Cave Sandstone, in which the fossils are large animals and bits of tree trunks and other plant stems such as might have been entombed in a mud, all point to the volcanic origin of the Cave Sandstone. The discovery by Mr. du Toit of pond deposits intercalated in the Cave Sandstone full of phyllopods, remains of cockroaches and other land insects, is further evidence that the Cave Sandstone was not formed under water.[†]

At Ascension Darwin noticed a white earthy stone forming in places isolated hills, at others associated with columnar trachyte (?) He was struck with its resemblance to a sedimentary tuff, but he ruled out the supposition owing to his inability to explain the presence of crystals of felspar, black microscopical specks and small stains of a dark colour occurring in proportional numbers in an aqueous deposit; he imagined, therefore, that the rock was a mass of trachyte that had been weathered completely through and through. I have no access to a more recent or better description of the rock, for the *Challenger* Reports contain only guesses as to what Darwin's rock may have been. Ehrenberg[‡] has described a white rock occurring at the Devil's Riding School as a pyrobiolith, that is a tuff containing minute organic particles, and in the *Challenger* Reports[§] this same rock is said to be made up almost entirely of the siliceous particles of grasses, and not of diatoms. Prestwich thought that the diatoms lived in underground waters which became caught up in the ascending lava.[||] May this rock not be a mass of volcanic ash mixed with boiling water that poured over a land surface covered with tall grasses? Had the mud been hotter the silica would have been fused, as when a hay-stack burns. This rock, then, would have been similar in origin to the Italian peperino, and, as we shall see later, to the Cave Sandstone. Whether Darwin's white rock is this, or is merely a trachytic tuff of which several are described in the *Challenger* Reports, must remain uncertain. I think, however, taking into consideration Darwin's mention of the fragments of granite ejected with the other materials of the tuffs, that some of this peculiar white rock, at any rate, is the same as the Cave Sandstone.

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[*] See "Volcanoes of Griqualand East," Trans. Phil. Soc., vol. xiv. p. 98, Cape Town, 1903.

[†] Ann. Rep. Geol. Comm. 1904.

[‡] Ueber einen bedeutenden Infusorien haltenden Vulkanischen Ashen Tuff (Pyrobiolith) auf der Insel Ascension, Berichte d.k. Akad. d. Wiss, Berlin, 1845, p. 140.

[§] "Chemistry and Physics," II., VII., p. 42.

[||] Proc. Roy. Soc., 1886, No. 246, p. 156.

Dunn, in 1874,* drew attention to what he called peperino beds in the strata overlying the Molteno beds. By this term he meant the beds of ashes apart from the Cave Sandstone. Ash beds occur in conjunction with the Cave Sandstone in some places, for instance, in Matatiele, and the description of the peperino of Monte Albano is strikingly like that of the Cave Sandstone in many respects. The Italian peperino consists of a ground-mass of tuff, in which sometimes angular fragments of rock are embedded. The ground-mass is light grey, fine and earthy, somewhat rough to the touch, and often porous; the drusy character shows that it was once saturated with moisture. The cavities are filled with zeolites and calcite, the material of which has been derived from the rock itself. The porosity, however, is not a constant characteristic of the rock. Light, unaltered spaces in the ground-mass alternate with darker patches, which may be explained by the action of acid vapours, according to Di Tucci.†

Microscopical examination shows that the ground-mass of the peperino is composed of minute particles of volcanic glass which enclose numerous crystals of augite and leucite. These glass particles are attached to each other by an indeterminate grey substance. Besides the glass, there are larger particles of mica, augite, olivine, magnetite, leucite, and fragments of basalt and leucitophyre, as well as limestone. These latter rocks occur as the finest dust which can only be recognised under the microscope, and also as larger blocks which are sometimes of very great size. Plant remains also occur. The peperino occurs in beds sometimes 800 feet thick, and is divided sometimes by beds of loose ashes, though for the most part it occurs as one great unstratified mass.

Suppose, now, that the volcanic glass in the peperino was replaced by dust composed of the triturated rock fragments torn from the throat of the volcano, we get an almost identical rock to the Cave Sandstone. To take the resemblances point by point:—

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* Report on the Stormberg Coalfields.

† Saggio di studi geologici sui peperini del Lazio. Real Accad. dei Luicei, Rome, 1879.

Both contain cavities filled in with zeolites; in the Cave Sandstone agates replace the calcite amygdules, a natural consequence on the difference in basicity.

Both contain patches of lighter and darker material, which character is also present in Darwin's white rock from Ascension.

Both contain fossils such as might be entombed in a liquid mud.

Both are made of minute fragments of non-volcanic rocks; in the peperino only to a small extent, in the Cave Sandstone generally to the exclusion of volcanic particles, but patches do occur in which there are volcanic fragments.

Both are volcanic products, and both attain a maximum thickness of 800 ft., but the continuous area of the Cave Sandstone is greater than that of the Italian rock.

Both are nearly always solid, unbedded masses, but both occasionally are separated by ash beds.

Both are the result of the activity of a great number of vents.

The peperino is supposed to have poured out as a mud. Pongi* maintains that it came up in the throat as a mud, like in the case of the mud volcanoes of Java and South America, but other authors hold that it is only a volcanic tuff which has obtained its water from the atmosphere either from rain or from masses of snow.† The teaching of the Kimberley pipes seems to point to the fact that Pongi was right, but the matter is very hard to adjudicate on.

In the Cave Sandstone we have many peculiar features that could be explained by the supposition that it flowed out from the crater mouths as a mud. For instance, it is hard otherwise to account for the immense thickness of the embedded mass; it is hard to explain the sudden change of great thicknesses of the white rock to a red clayey material; and still more mysterious is the pseudo-bedding that one can see at N'quatsha's Nek, where the stratification is just such as would be produced had the whole been stirred round in a gigantic pot like a pudding. The relation of the present river drainage to the chain of volcanoes shows that the whole area must have been dry land, and the sub-aqueous origin of the Cave Sandstone must, therefore, be considered very doubtful. Leopold Von Buch‡ thought the Italian peperino had been deposited in the sea, but it can be proved that this rock, at any rate, was never under water, so the parallelism between the two rocks is further brought out from the history of the theories regarding their origin.

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* Reale Accad. dei Luicei, Rome, 1879–80, Memorie.

† Branco, "Swabens 125 Vulkan Embryonen," p. 699.

‡ "Geognostische Beobachtungen auf Reisen," Teil II., Berlin, 1809, p. 70.

I have brought these facts together to show that in the Tonga Islands, in Tristan d'Acunha, and in Ascension there are signs of volcanic tuffs made up of non-volcanic material like the Cave Sandstone, and that the dust of which they are composed must have been torn off cold from the throat of the volcano, and that the rocks which surround the throat are of ordinary continental types of rock.

To pass these facts in review, we find that we can commence with an example like the Island of Trinidad or the Falkland Islands, which stand, without doubt, on a continental shelf. Then we have an island like South Georgia, or New Caledonia, which, though surrounded on all sides by open water of 1,000 to 2,000 fathoms depth, yet bear such unmistakable signs of belonging to a continental area that there has never been any doubt of the fact. Then we have the Fiji group, an isolated collection of volcanic peaks separated from New Caledonia by a wide stretch of deep ocean, still unmistakably showing their continental origin from the nature of the base on which they stand. Then we have the Tonga group, as truly oceanic as any island can be, still affording evidence of having a continental base. And, finally, the Lesser Antilles, showing no direct evidence of continental origin, yet standing on a ridge, the two ends of which come to the surface at Trinidad and Puerto Rico, and show that the whole is composed of continental types of rock.

With such evidence before us, can we still assert that the oceanic islands are volcanic cones rising from the abysmal depths of the sea, and that the ocean floor from which they spring is made of a type of rock different from that which forms the continents? For my part I think that we have sufficiently clear proof that they all spring from continental ridges, and that the outer crust of the earth is uniform in composition throughout the continents, and throughout the area covered by the ocean.

What, after all, are volcanoes? If we fix our attention on those in eruption, or which are still in the condition in which they were when they were active, we can easily be led to believe that they are vents that reach down to the molten, or potentially molten, interior of the earth. But when we come to examine the volcanoes of an earlier age, and those which have been dissected by long continued processes of denudation, we come to a deep-seated base of plutonic rocks, granites, gabbros, &c., and we come to regard the lavas as the more easily melted scum that is driven off from an immensely greater area that remains behind to re-solidify slowly in the great depths. These residual masses of rock are not composed of materials of great specific gravity such as we would expect if the volcanic vents really did go down to enormous depths, but are precisely similar in average density to the ordinary sedimentary rocks of the surface.

In South Africa we have had our attention riveted to two classes of igneous action: the intrusion of basic rocks in strata already existing and the extrusion of lavas on the surface. Both are probably accompanied with the formation of vents filled with non-volcanic material, these tuff- and boulder-filled pipes of the former group being connected with the great dolorite intrusions to which, however, they are subsequent; while the lavas are connected with the boulder- and tuff-filled necks which were formed both previously to, and contemporaneously with, the extrusion of liquid rock.

There is a third kind of volcanic activity which finds its expression in the vast masses of amygdaloidal melaphyre that apparently welled up through great fissures without the accompaniment of volcanoes. In the Colony Mr. Rogers and I have studied them in the Prieska Division,* and they are in all respects similar to the Bushveld amygdaloid in the Transvaal. These are probably connected with vents filled with rhyolite and acid breccias which occur in the Hope Town Division, but they are too little understood to contribute to my argument. All we know about them is that they are exceedingly ancient, being found intruded among rocks which, if lithological similarity can be taken as a guide, are Archæan, the Indian Vindhyan rocks and the Lake Superior iron-bearing series, being the same not only in composition but in the order of the superposition of the several members.

The first two groups are connected with great movements in the earth's crust.

In Willowmore we get masses of quartzite belonging to the Table Mountain series crushed and ground to powder as if caught in the jaws of an enormous press. The brecciated rock occurs at the crossing of two systems of folds. The cubic content of one of these masses in Baviaan's Kloof, which could be actually seen and measured, was over a cubic mile. I have referred to this phenomena already,† and have shown that the enormous force requisite to crush such a vast mass of the most resistant rock would, had there been a flux or had the material been of a less refractive nature, resulted in the fusion of the mass.

Mallet held much the same views. He says: "The result of the crushing is to produce irregular masses of pulverised rock, heated more or less highly, that may extend to any depth within the earth's crust; but it is only to such depths as water can percolate that the deepest focus of volcanic activity can be found."* In the Drakensberg the volcanoes are situated on a line of crustal deformation.† A large number of the vents have brought only solid rocks to the surface, fragment and boulders of granite and crystalline schists—though I had only to record the presence of a single fragment of crystalline limestone among the boulders in Matatiele, yet the tuffs are sufficiently good evidence to ground my argument upon with this isolated boulder, for I unfortunately had a very limited time in which to prosecute my investigations, and was hindered by the regulations consequent on the war that was then raging while I was surveying the Matatiele Division, and, also, I was working in an altogether new area. It is very improbable that a single boulder of the older series should exist in the whole district.

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* Ann. Rep. Geol. Comm., 1899, Cape Town, 1900.

† Hot Springs, Geol. Mag., 1904, p. 252; Ann. Rep. Geol, Comm., 1903, Cape Town, 1904, p. 133.

Round Molteno there are a number of vents, of which Telemachus Kop is the largest; Mr. Dunn says that among the rocks in the neck there are many that are quite unlike any in the district. Mr. du Toit, also, in Elliot ‡ found bluish white quartzites that are probably derived from the Table Mountain series or perhaps from the Dwyka conglomerate lying between the Table Mountain sandstone and the newer sedimentaries. In Sutherland Mr. Rogers definitely records Table Mountain sandstone in the pipes in the Saltpetre Kop area along with granites, mica-schist, grits, and shales, so that the rock did undoubtedly come from the underlying basement of the Karroo sedimentaries.§

The simple fact of having these solid rocks brought up in the volcanic pipes, proves to my mind that the chimneys cannot have their origin in really profound depths in the earth's crust, for had they so penetrated, the enormous pressure that exists at such depths would have brought the molten rock welling to the surface to the exclusion of all solid material. We seem, therefore, in the Drakensberg to get what was wanting in the Baviaan's Kloof folded area, namely, an enormous force applied to a rock-mass containing a flux, and sufficiently deep in the earth's crust to keep the fracturing of the rock under, and thus to concentrate the effects of the force. As the mass acted upon contained limestone, as witness again the limestone boulder, and the rest of the material was granite and crystalline schists, as witness the nature of the Cave Sandstone, the mass resulting from the fusion together of the basic and acid types of rock resulted in the production of moderately basic types of igneous rocks, which are the lavas of the Drakensberg.

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* Phil. Trans., vol. clxiii. p. 167.

† Volcanoes of Griqualand East, Trans. Phil. Soc., Cape Town, 1903, vol. xiv. p. 98; Ann. Rep. Geol. Comm., 1902, Cape Town, 1903, p. 39.

‡ Ann. Rep. Geol. Comm., 1903, Cape Town, 1904, p. 193.

§ Ibid., pp. 61-63.

In the Sutherland and Kimberley pipes I have said that they are probably connected with the intrusion of the dolerite. My line of argument is that, during the deposition of sediment in Karroo times, the floor on which they rested was obliged to sink. In doing so, the deeper layers stretched, and being already consolidated, they tended to crack. The rock at such great depths is in an unstable condition, half too refractive to melt under the pressure, and half sufficiently fusible to do so, hence the material that became molten was forced up into that which had fractured under the pressure, and the dolerite of the Karroo was thereby injected into the strata along pre-existing cracks formed by the bending of the sediments. The age of this intrusion is fixed between fairly narrow limits; it was after the deposition of the Ecca beds,[*] for they are found south of the folded mountain region in Robertson, and took place before the close of the Cretaceous period, for borders of dolerite occur in the coarse conglomerates of that formation in Pondoland.[†]

The whole series of Karroo rocks now became heated by the addition of so much intensely-hot material, and there are exceedingly interesting phenomena connected with this stage, as, for instance, the distillation of coaly material into vertical cracks at Leeuw River's Poort and in the Cambdeboo Mountains.[‡] Heated rock, like every other kind of material, expands, and, as a result, the rocks exerted a tremendous lateral push.

There is a great deal of doubt as to how far a lateral stress can be communicated along a mass of rock. In experimental examples the most interesting is Mr. Reade's observation on terra-cotta copings set in cement. These, forming the top of a wall, were exposed to the sun's rays, and expanded, pushing the neighbouring one aside or riding over it.[§] The same effect is shown by the same author in his book on the "Evolution of Earth Structure," in the case of a sheet of lead, where prolonged alternations of heat and cold resulted in the raising of an anticlinical ridge, the whole effect of the expansion being transmitted along the sheet of flexible metal which was not held down by any cement, yet the relief took place along one line only.

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[*] Ann. Rep. Geol. Comm., 1896, p. 28.

[†] Ibid., 1902, p. 44.

[‡] Ibid., 1902, Cape Town, 1903, p. 16.

[§] Geol. Mag., 1888, p. 26; "Evolution of Earth Structure," 1903, p. 204.

We have at least some evidence to go upon when we say that the heating of the Karroo rocks produced an expansion which became checked along the outer ridge of the structural basin, that is to say, on the outside of the Karroo, where a zone of old schists, slates, and granites exists. The lateral thrust expending itself against this buffer forced up the strata just within it in a series of folds which, on the south, form the folded mountain ranges of the colony. The thrust could not have come from the south, as the granite bars the way for the transmission of thrust in this direction.

At the other end of the expanding strata, where they abutted against the old pre-Cape rocks of Prieska and Griqualand West, there was no buckling, but the immense pressure, relieved though it was to the south by the formation of folds, resulted in some re-adjustment of the strata, the transmission of the stress not being perfectly free; and it seems that it was the buffer of old sedimentaries and granite that was crushed and not the Karroo rocks themselves (see Fig. 3).

The tearing and rending of the rock masses resulted in the ultimate fusion, the production of gases from the volatilisation of the water and carbonates held in the rocks, and the consequent production of the vertical pipes of Kimberley and neighbourhood. Very little truly molten matter resulted from the action of the Kimberley volcanoes; in Sutherland Mr. Rogers has recorded a good deal of melilite-basalt as occurring in the vents, but, in the great majority of cases, the pipes are filled with material that has merely been blown to fragments without fusion.

Looked at, therefore, in the light of actual evidence, Tristan d'Acunha with its volcano bringing up materials which show that it rests on a base of continental rocks goes far to add one more nail in the coffin of the theory of the Permanence of Ocean Basins, which the researches of Lester in the Tonga Islands and Woolnough in the Fiji Islands had already assailed along similar lines, a theory which has long held the field from the brilliancy of its advocacy by Mr. Wallace.

Looked at from the theoretical standpoint which our researches on the volcanoes of South Africa have led us to, namely, that volcanic action is not a deep-seated one, but the resultant of earth movements, the intensity of which, concentrated upon certain fusible portions of the strata affected, such as the limestones and dolerites and schists heavily charged with iron, gneisses and hornblende schists, melted these in some cases with the production of lava, and simply blew them to pieces at others with the formation of such rocks as the Cave Sandstone. Not only does this conception of the

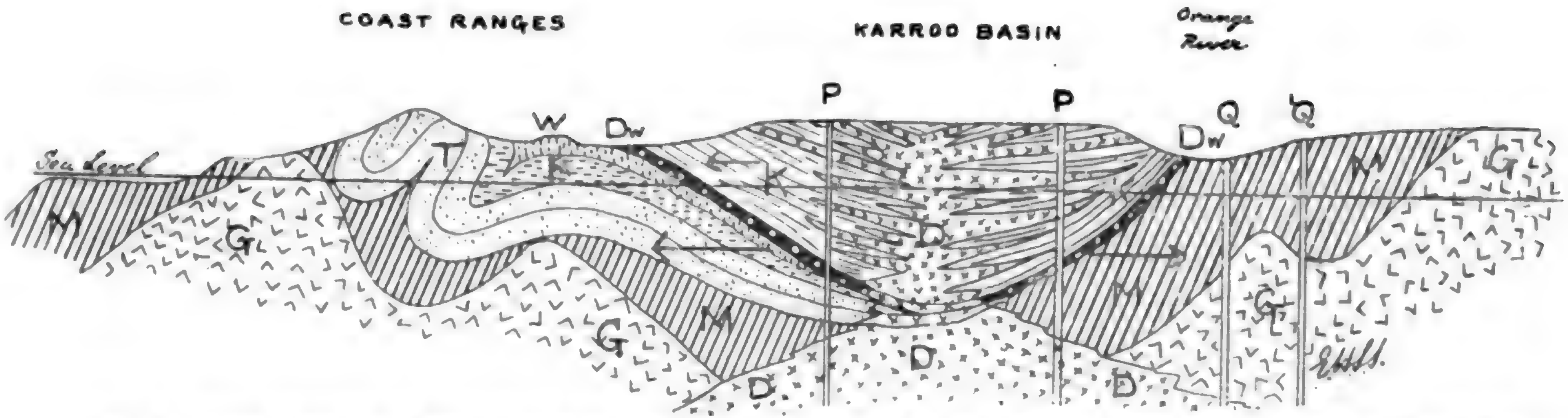

FIG. 3.—Section across the Karroo Basin from north to south. The drawing shows the beds much shortened and the dips correspondingly increased. The progressive amount of the unconformity below the Dwyka conglomerate is indicated. The dolerite probably never made a central plug as shown, but the liquid magma flowed upwards along a network of slanting cracks or lines of weakness. The amount of thrust due to the heating by the dolerite intrusion is indicated by horizontal arrows. The surface thrust on the north is nothing, on the south considerable, while the deep-seated thrust on the north was not so great probably as on the south. The dip of the strata forming the coastal ranges is produced by the increasing amount of the thrust as the depth becomes greater.

M, Pre-Cape Sedimentary Beds. **G**, Granite and Gneiss. **T**, Table Mountain Series. **B**, Bokkeveld Beds. **W**, Witteberg Beds. **Dw**, Dwyka Series. **K**, Karroo Series. **D**, Dolerite. **P**, Volcanic Pipes containing no diamonds. **Q**, Kimberley Series of pipes containing diamonds.

The two places where the granite comes to the surface may be regarded as the buffers against which the pressure of the expansion was expended. That on the north has probably been land for a very great age, that on the south is part of the Madagascar ridge that has now sunk beneath the ocean.

The thinning out of the Cape Formation northwards is due to Pre-Dwyka denudation, and does not indicate that the sediments were derived from the south; the evidence that we gather from a consideration of the distribution of the succeeding formation, the Bokkeveld Beds, as shown in Fig. 1, leads us to conclude that these Cape Formation strata are derived from the denudation of the northern continent. N.B.—The Dwyka and Ecca Beds occur south of the folded ranges at Robertson.

nature of volcanic action help us in the understanding of the South African occurrences, but it is in accord with a large number of facts which have previously been the cause of much speculation, such as the small depth of the origin of earthquake tremors previous to volcanic eruptions, and the production of mud-volcanoes vomiting boiled fish. It also explains the situation of volcanoes like those forming the Galapagos Islands on the points of intersection of two sets of folds acting at right angles to each other, the tearing and rending being naturally greatest at these structural nodes.

The well-known fact that volcanoes do occur on structural displacements can now receive a new interpretation; no longer do we conceive these folds opening great cracks that penetrated to the molten interior of the earth, thus violating all the laws of Isostacy, or what was known before the Americans called the equilibrium of the earth's crust by this name, namely, the closure of fissures at great depths owing to the pressure that the weight of rock exerts, but we look to these structural lines as the actual seat of the fusion of the rock, the motion and friction of the bending and shearing being translated into heat, and the volcanoes thus naturally forming on these lines.

The question of whether the sedimentary rocks and the older crystalline series in their immense variety can, when fused together in different proportions, give rise to the various kinds of igneous rocks, is too large a one to go into here, and is a matter of compilation of rock analyses, which, with skilful arrangement, could be made to prove or disprove the theory. The only difficulty that I have come upon in thinking the matter over is the great amount of titanium in our Kimberley and Sutherland pipes, but the difficulty is of the same order as the presence of manganese at Wellington and Hout's Bay, which has formed from solution and redeposition from waters soaking out from the Table Mountain sandstone, a rock that is stained blue with iron sulphides.

There is a fairly general concensus of opinion that the view of the interior of the earth as set forth by Prof. Judd in his edition of Scrope's "Volcanoes," and endorsed by Prof. Suess,* is correct, namely, that the interior of the earth is composed of a heavy metallic centre, surrounded by a siliceous slag. If volcanoes do, therefore, penetrate to the great depths, would they not bring great masses of metallic substances with them to the surface like the nickeliferous iron of Ovifak in Greenland? Not a single oceanic island composed of volcanic rocks has yielded a mine of any sort of metal.

That volcanoes have nothing whatever to do with the molten interior of the earth is very clearly brought out in Prof. Vogt's researches, where he shows that the basic and acid rocks of continental types are each characterised by metals, each group having peculiar metals associated with them. These continental types of igneous rock are solidified portions of the earth's interior, that is to say, they are the original fundamental rock that has had no alterations in its constitution brought about by denudation, deposition, or re-melting. The following table given by Prof. Vogt is expressive. It shows the preponderance of certain metals in the two groups of rocks:—

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* *Nature*, vol. lxiv. p. 629.

ACID IGNEOUS ROCKS.	BASIC IGNEOUS ROCKS.
Silicon to a great extent.	Silicon to a less extent.
Potassium and lithium.	
	Barium and strontium.
Beryllium.	Magnesium.
	Aluminium.
	Iron, manganese, nickel, and cobalt.
Wolfram, uranium, and molybdenum.	Chromium.
Tantalum, niobium.	Vanadium.
Cerium, yttrium.	
Tin, zirkonium, thorium.	Titanium.
	Gold, platinum, iridium, osmium.
Boron.	Phosphorus.
	Sulphur.
Fluorine.	Chlorine.[*]

The teaching of the above list is to show that when the rocks are in earth's crust below the zone of the existence of stratified rock, that there is a magnetic differentiation, and that there is a separation into two groups, acid and basic. Each group attracts to itself certain elements, including a certain proportion of metals. We find, too, that this differentiation goes on side by side, and is not affected by the distance from the earth's centre. Given, therefore, that the crust of the earth is a slaggy, siliceous mass supported on a metallic centre, the teaching of Vogt's work shows that the slaggy material separates out according to some law of the mutual affinities of the elements, rather than the simple action of gravity on the elements composing the rock magma, according to their densities. We enter on a field of research in which volcanoes have no part, and we see that oceanic volcanic islands are not composed of the material of which the normal original basic rocks of the earth's crust consist.

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[*] Ueber die relative Verbreitung der Elemente, besonders der Schwermetalle, und die Concentration des ursprünglich fein vertheilten Metallgehattes zu Erzlagerstathen, J. H. L. Vogt, "Zeitschrift praktische geologie," 1898, p. 314.

Dr. Sterry Hunt was led by an altogether different train of reasoning to come to much the same result, namely, that volcanic lavas are re-melted portions of sedimentary beds; he considered the water in volcanic rocks to be that which they had originally held when deposited in the ordinary way,* and that they were rendered fluid by the under surface being forced into the region of rock fusion.

In conclusion, I have brought forward evidence to show that a continental ridge crossed the Atlantic from Africa to South America; it probably extended from Cape San Roque, through St. Paul's rocks to Sierra Leone on the north, and from the south of Brazil, through Tristan d'Acunha to the Cape of Good Hope on the south; it probably existed from Devonian to late Tertiary times.

I have shown that oceanic islands are not exclusively volcanic, but that the materials found among their ejactamenta contain certain types of rock that are known as continental.

I have shown that volcanoes are not caused by pipes that reach to the profound depths of the earth and tap a problematical molten magma, but are more probably due to the heat caused by the crushing of rocks along structural lines.

I have shown that the true normal original rocks of the earth's crust are profoundly different from the basic rocks of volcanic eruptions. It follows, then, that the Tristan d'Acunha group, though volcanic, stands on a continental ridge, and the volcanoes of which it is composed are the result of a fusion of continental types of rock.

And in regard to the permanence of ocean basins I have brought forward clear evidence that continental types of rocks underlie the great oceans, and that, therefore, the confinement of the waters to their present area throughout geological time must be considered to be unlikely.

TRISTAN D'ACUNHA.

Slide No. 1139. Basalt.

A dense stony nodule, slaty black, and mottled on the outside with little white rounded spots.

Under the microscope:—

A very fine crystalline matrix remarkably even in texture, composed of minute laths of felspar, all perfectly formed and terminated by definite crystalline boundaries. The laths are all extended in one direction, very few lying diagonally; they average ·01 millimetres in breadth.

The augite is in very fine granules, but frequently shows crystalline form; they are for the most part very minute, ·005 millimetres or so, but a few larger ones occur.

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* Trans. Cambridge Phil. Soc., vol. xii. p. 414.

About equal in numbers with the augite, and of the same sizes, there are specks of iron ore. There is no residual glass.

Small rounded patches crowded with iron ore indicate portions of the magma that have cooled rapidly, the felspar laths wrap round such areas, and thus show that the inclusion of these little specks is due to motion during the flow of the molten material.

In the matrix there are abundant large crystals of iron ore and often enclosing portions of the microcrystalline base. They frequently seem to have gathered round them the augite and iron ore granules to the exclusion of the felspar; the laths of the last mineral wrap round the whole.

Very rarely porphyritic crystals of the augite and large laths of the felspar occur. The augite is strongly refractive and sometimes pleochroic from bright yellow to colourless; round the edges there is a thin zone of more ferruginous material, indicating fusion at the periphery. The felspar laths are about ·1 millimetre in breadth and show fusion at the ends, giving the laths a spindle shape; minute augite granules have grown up on the fused portion, showing a certain amount of transfusion.

Slide No. 1140. Basalt or andesite.

A puce-coloured, stony matrix, crowded with large black augite crystals, about $\frac{1}{8}$ inch in diameter, and white flecks of felspar. The augite is tarnished with iridescent colours.

Under the microscope:—

Matrix the same as the last, only the laths are more irregularly placed, though they still show flow structure, and there is a sprinkling of larger augite crystals.

Porphyritic crystals of large size include magnetite, augite and labradorite. A few small granules of olivine.

The augite is in large crystals, enclosing felspar, magnetite, and sometimes smaller grains of augite, with which the larger crystal has not grown up in sympathy.

The labradorite is in square, stumpy forms, often showing the albite as well as the pericline twinning. Sometimes the stumpy laths form star-shaped aggregates, but, as a rule, the crystals are not lath-shaped. The large untwinned crystals frequently show zoning and shadowy extinction, with more basic interiors. They enclose granules of augite.

Olivines, mostly in small grains, but sometimes larger ones occur, showing crystalline faces.

Slide No 1141. Basalt. A dense grey, stony rock, with lighter spots on the outer surface.

Under the microscope:—

The same as 1139, with larger granules, and without the flow structure. The section is very transparent, and the boundaries of the minutest augite granule can be distinctly seen. There is a great amount of residual glass, which is a half-formed felspathic mass.

Slide No. 1142. Basaltic glass. A dense black lava, with small vesicles; rounded patches, containing somewhat larger vesicles, occur throughout it.

Under the microscope:—

The rock consists of two portions. The one or more normal type is a glass full of black granules, in which long laths of felspar are confusedly set. There are a number of small rounded vesicles, the rims containing a brownish limonitic glass, less dense than the main mass. The other kind, which penetrates the first with a definite black line between the two, is composed of the same glassy matrix, more discoloured by weathering. In this last there are large irregular vesicles, bordered by a wide zone of clear, colourless glass. In the interior of the vesicles there is a brownish opaque deposit.

Slide No. 1143. Basalt or andesite. A friable, light and dark grey mottled, stony rock with crystals of augite.

Under the microscope:—

The same as Slide No. 1140, with larger granules, and a good deal of residual glass.

The augites show twinning, with re-entrant angles and zonal structure, also inclusions of olivine and magnetite.

The felspars show Carlsbad twinning and zoning, also rims of growth or alteration.

The olivine is very fresh, usually associated with magnetite; it does not show crystalline boundaries, but is not corroded.

The matrix is composed of felspar laths, enstatite, and magnetite. The enstatite is granular only, some of the larger individuals show the lath-form giving straight extinction and the rhombic section, with the little glass tubule in the centre. There is a certain amount of flow structure shown in the laths wrapping round the larger magnetite crystals and the other porphyritic minerals.

Slide No. 1144. Basalt. A stony, vesicular rock with many crystals of augite.

Under the microscope:—

Large crystals of augite, felspar, olivine, and magnetite, set in a microcrystalline base.

The augite is in large crystals often intergrown with magnetite, and enclosing small granules of olivine; it frequently shows twinning and zonal structure.

The felspars are large individuals, having the vitreous look of sanidine; they are twinned on the Carlsbad and Baveno systems, though the bigger crystals are often unstriated, they are probably labradorite from measurement of the angles of extinction. The lath-shaped striated crystals sometimes are aggregated in radiating bunches.

The olivine is rare, with little brown alteration products round the outside; it is often adpressed against larger crystals of magnetite, and is included as granules in the large augites.

The matrix is composed of felspar laths, augite, enstatite, magnetite, and glass.

The felspar laths are very frail things, showing incomplete growth, and seldom show a definite termination. The larger forms include a quantity of the matrix.

The augite is in small, ill-formed, light wine-red laths, giving oblique extinction, and is not so strongly refractive as the enstatite, with which it is often intergrown. The crystal forms tend to the simple prism and basal plane, and the minute crystal laths often show the hour-glass structure.

The enstatite is in more refractive laths, giving straight extinction and rhombic sections, and is not so plentiful as the augite; it is slightly coloured yellow. Down the centre there is the characteristic tubular space filled in with glass.

The magnetite is in crystals and granules.

The glass is colourless, with minute colourless refractive hair-like growths. An isotropic mineral, sometimes showing hexagonal sections, at others irregular, is probably one of the felspathoids, or their alteration product, analcime; the great rarity of the mineral makes it impossible to determine it; it contains the same hair-like crystals as the glass.

Slide
No. 1145.
Trachyte?

A fine-grained, creamy-coloured rock, resembling a tuff in appearance, with rounded patches of coarser materials; in a similar but harder sample, large sanidine can be seen with the naked eye. This loose tuff has many points of similarity with the black basaltic-looking rock from Nightingale Island (Slide No. 1152).

The matrix is a felspathic paste, on which there are ill-formed laths and dusty granules of exceedingly minute size. The laths are incipient felspar, while the bright yellow microlites and granules agree with augite. A number of small crystals and grains of zircon also occur in the mass.

In this base there are large crystals of sanidine, hornblende, and sphene.

The sanidine is in straight laths, very fresh internally, with dusty alteration products round the edges and along the cleavage cracks.

The hornblende is very interesting; it is surrounded by a halo of alteration products, principally bright yellow augite and magnetite. In Slide No. 1147 there are similar sections, in which all original mineral substance has been changed to a mixture of magnetite, augite and felspar. What we see in the present slide is probably an early stage of what we see in No. 1147, in which the ferro-magnesian mineral, caught in the molten magma, has been wholly metamorphosed.

The sphene is in large crystals, greyish yellow, with characteristic shagreened surface, marginal reflexion, and high interference colours. The mineral is also curiously abundant in the rock (Slide No. 1152) from Nightingale Island, and is also characteristic of one of the *Challenger* rock specimens from the Falkland Islands. This last is so interesting that it may be well to set down the Rev. Renard's description of it, especially as attention has primarily been directed to the non-volcanic series in these islands. It is a fine-grained felspathic sandstone, formed of an aggregate of quartz and felspar grains, containing fragments of mica-schist, glassy vesicular lavas and red porphyries, plagioclase felspar, quartz, and sphene, with scales of chlorite.

Besides these comparatively unaltered elements, there are patches composed of aggregates of magnetite and augite granules, evidently the altered remnants of ferro-magnesian minerals.

The rock seems to be similar in microscopical characters to the amphibolic andesite containing sanidine of the *Challenger* rocks, but I believe the rock is an originally basic rock which has picked up and, to a certain extent, absorbed fragments of a porphyritic acid type.

Slide No. 1146. Basalt.

A red vesicular bomb; matrix hard and stony. Open spaces filled with powdery white growths turning yellow on the exterior. There is no rim of anything of the nature of a cooled outer surface. Plenty of large augite crystals.

Under the microscope:—

An opaque mass with minute laths of felspar and granules of augite and olivine forming the matrix.

Porphyritic crystals of augite, enstatite and olivine, all with many enclosures.

The augite is in large, simple and twinned crystals; they enclose large irregular spaces filled with the opaque matrix; in one instance the plane of composition of the twin is the seat of a large zone of matrix, which contains olivine grains.

The enstatite is in large crystals with the same shagreened surface as the olivine, but with low interference colours. It is slightly coloured yellow, weakly pleochroic to blue, in contrast to the olivine, which is quite clear and colourless. The crystals show no decomposition along the cleavage cracks, while the olivine has red stains along the cracks. The enstatite has been corroded, and portions of the matrix dip into the substance of the crystals, making pegs and mushroom-shaped indentations; the olivine is not corroded. The enstatite has rounded enclosures of the opaque glass, the olivine shows no inclusions.

The olivine is in clearly-defined crystals, showing forms with dome faces without the basal plane.

Very rarely there is a small porphyritic crystal of plagioclase, in stout columnar forms, with perfect crystalline contours except for a little corrosion along the sides. Inclusions of glass occur in strings along the axis of the prisms.

Slide
No. 1147.
Basalt.

A grey rock with lighter rounded spots, stony, and showing fluidal parting planes, crystals of augite.

Under the microscope:—

Matrix, a fine-grained aggregate of well-formed felspar laths, augite granules, strongly pleochroic biotite and magnetite, with a good deal of clear residual glass showing a certain amount of bi-refringence. There is a distinct flow-structure.

Porphyritic crystals of augite, olivine felspar and magnetite.

The augite is in aggregates that seem to have been crushed together, though some are intergrown crosswise. The larger specimens show zoning and inclusions of felspar laths and magnetite; their edges have been melted and recrystallised in the less basic variety of augite as shown in the clearer granular forms of the matrix.

The olivines are in irregular crystals, very clear and fresh with inclusions of magnetite and sometimes forming, as it were, small adjuncts to the larger magnetites.

The felspars are striated and are sometimes altered with development of zoisite, otherwise they show a great number of inclusions arranged along the crystalline axis; the ends are corroded.

There are darker patches in the matrix showing crystalline boundaries which are fused ferro-magnesian minerals; they are composed of the same augite and magnetite as the general ground-mass, but the latter mineral is in far greater proportion; some felspar substance is also present. One of them shows a residual portion of augite; therefore it is probable that these patches represent crystals that have got into the magma from previously consolidated lava. From the similarity in Slide No. 1145, where the hornblende is altered, I have thought that perhaps these patches represent melted up portions of extraneous rocks, and the unusual presence of brown mica in great quantities in the matrix lends some sort of support to this view.

The magnetite is in large crystals, and has grown up with it crystals of augite, olivine and plagioclase. The felspar laths of the matrix show a streaming round the crystals, stronger than those for any of the other porphyritic crystals.

Slide No. 1148. Vesicular Basalt.

A slaggy, ropy, vesicular red lava, with crystals of augite.

Under the microscope:—

An opaque matrix with laths of felspar blown into a network, with rounded vesicles.

Large porphyritic crystals of augite, olivine and felspar, with occasional black stony patches, representing inclusions of dirt.

The augite is in large, sharply-bounded crystals with zoned edges; sometimes it occurs also in little aggregates of stumpy columns.

The olivine is quite fresh, with glass inclusions; it sometimes is in irregular forms grown up with magnetite.

The plagioclase is sometimes in very large individuals; it shows inclusions of glass which form a sort of reticulation. There is a certain amount of alteration to zoisite. The end portions of the larger crystals are sometimes bent.

Slide No. 1149.

An inky black vesicular bomb, in which the vesicles are far larger in the periphery, where they are coated with a brownish-red deposit. Towards the centre the rock becomes less vesicular, and in the centre it becomes a ropy fibrous glass, the strands, as it were, separated from each other.

Under the microscope:—

The matrix is a brown granular glass crowded with minute granules of magnetite, through which the felspar laths show somewhat shadowy. Only one porphyritic crystal is apparent; it is an augite, one part of which has been changed to, or has had included in it, brown hornblende.

Slide No. 1150. Gneiss.

A white mica and biotite gneiss, showing well-marked partings caused by the aggregation of mica plates. The whole boulder is rounded as if water-worn.

Under the microscope :—

Biotite in normal pleochroic brown plates, sometimes with a non-pleochroic feebly doubly refractive green alteration product. The muscovite is also quite normal and very fresh.

Quartz in large proportion, showing hackly borders and a certain amount of dusty matter between the contiguous grains. No large fluidal cavities, though dusty inclusions occur, which may be minute cavities or merely dust; slender apatite needles and trichite-like crystals also are present. Some of the grains show strain effects, as if there had been an attempt to granulate the whole, this appearance under crossed nicols.

The felspars are microcline, with streaks of albite, showing almost invariably the microperthite structure.

There are some patches of isotropic substance, clear and colourless, with strong single refraction; the substance falls out in grinding the section, so that it is difficult to say what the mineral is. The most likely suggestion is garnet.

Slide No. 1151.

A red stony lava with irregular-rounded vesicles, compressed and flattened

Under the microscope :—

An opaque glass with dusty granules and well-formed laths of felspar. The small, rare porphyritic crystals are augite.

NIGHTINGALE ISLAND.

Slide No. 1152. Andesitic glass.

A fine-grained, semi-crystalline, blackish rock, with scattered little laths of felspar; sheared, and weathers with a pitted surface.

Under the microscope :—

A fine, transparent glass containing microscopic rods of augite and ill-formed laths of felspar.

The augite is in very minute lath-shaped crystals; the felspar laths, as is often the case where the augite is crystalline and not granular, seems hardly to have crystallised out of the glassy base, which is an indefinite felspathic mass. Magnetite is wholly subordinate and exists in granules. Long apatite needles sharply terminated by the simple pyramid, sometimes grown together in parallel position, at others showing the characteristic transverse cracks, the separate portions of the needle being sometimes quite far apart; they are of a light wine colour in the centre, showing feeble pleochroism with greatest absorption along the trace of the short axis of the nicol.

In this paste there are mineral aggregates, which appear to be the shattered remains of a previously consolidated rock.

The included fragments are :—

A little aggregate of orthoclase, plagioclase, biotite, sphene, magnetite, apatite, and chlorite ; the junction of the minerals is obscured by an alteration product with the interference colours of calcite. Little flecks of white mica are developing on the felspars besides dusty alteration products.

The orthoclase grains are in untwinned lumps showing shadowy strain extinction, and also in little clear Carlsbad twins. The plagioclase is closely striated. The biotite is an irregular piece showing the usual strong absorption when the cleavage lies parallel with the short axis of the nicol. The sphene has a rim of titaniferous iron. The chlorite is in a scale with very low bluish interference colours. The felspar crystals show frayed ends where they have been partly dissolved in the liquid magma, but along the sides the minute laths of the matrix lie parallel to them without melting. As usual, there is separation or segregation of magnetite near the ferro-magnesian constituent.

Another grain shows orthoclase, a slightly pleochroic augite, sphene and magnetite. The felspars have a rim of absorption in which, near the inner edge, there are little black tubules set at right angles to the edge. Apatite occurs also in minute rods.

Loose grains of orthoclase are found in the matrix showing sometimes clear rims of absorption. They are often associated with biotite.

Mica is common in detached flakes; round them there is a zone of clear crystalline substance full of magnetite granules.

Sphene is very abundant showing a feeble pleochroism. The shape of the crystals is characteristic, and the index of double refraction and strong dispersion point to the identification of this mineral.

Moderately pleochroic augites, yellow and greenish-blue, occur ; they have not the absorption rims of the biotite, and seem to have remained unaltered.

Magnetite grains are rounded previous to being embedded ; the felspar laths wrap round them, but there is no separation out of magnetite granules as there is round the biotite.

This extraordinary rock shows that the heat of its melting point was sufficient to attack the ends of the orthoclase crystals, but not sufficient to melt the sides ; it shows that it has the power of leaching out the iron from the biotites but not that of the augites, and apparently was powerless to act on the magnetite crystals. It shows that the derived fragments have not been subjected to long exposure to heat after being embedded.

INACCESSIBLE ISLAND.

Slide No. 1153. Enstatite felspar rock. Andesite.

A fine-grained, black basaltic rock, with small crystals of augite (enstatite ?), showing irridescent tarnish colours and enstatite ; vesicles much drawn out and compressed ; slaggy on the upper surface.

Under the microscope :—

A felted mass of laths showing a somewhat indistinct fluidal structure around the long drawn-out vesicles.

The greatest bulk of the crystals are felspar laths shown in some three grades of size, the smallest ones sometimes aggregated with fibrous brushes. The middle size are long, slender laths sometimes with sharp terminations, but the glassy matrix often dips into the termination, making it ragged; glass often also forms an axial string down the lengths of the laths. The largest size attain almost porphyritic dimensions and are crowded with irregular glass inclusions. The felspar laths are often clasped by the enstatite crystals. The larger felspars are monoclinic, that is, they are sanidine. The matrix is composed of felspar laths, enstatite, magnetite, and brown glass.

The enstatite is a light yellow, strongly refractive mineral showing in rhombic sections and square-ended laths ; the crystal form is unusual and is simply made of the prism and basal plane. Nearly always there is a tubular hollow down the centre filled with a honey-brown glass. The pinacoidal cleavage is often seen running diagonally across the rhombic sections, the crystals, however, usually break up with irregular cracks. Interference colours never exceed yellow. The average breadth of the laths is ·02 mm., but some are larger ; there is a number of minute granules of the same mineral in the matrix. Rarely the enstatite has adherent to it a crystal of magnetite, but there is no increase in the iron content of the silicate which would be shown by a higher colour and consequent pleochroism. The macropinacoids are sometimes present ; rarely the laths are grown together in a bunch. The very small crystals of the matrix often show the prisms with the more usual pointed terminations caused by the presence of the macrodomes.

THE FORMING OF THE DRAKENSBERG.

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I.—Introduction.

The Drakensberg is the south-eastern edge of the great tract of high ground forming Basutoland. It extends northwards to form the boundary between Natal and the Orange River Colony, while its prolongation westwards forms the Stormberg area. Though of extreme interest geologically, the Drakensberg has not attracted very much attention from South African geologists, and papers upon its geology and mineralogy are but few; among the most important are those by Cohen, Dunn, Churchill, and Schwarz. The recent geological survey of a considerable area around Elliot, Barkly East, and on the Basutoland border, has yielded a large amount of information concerning the rocks composing this portion of the Drakensberg and their geological history.

According to all authorities the character of the rocks varies but little over an immense area, and it is almost safe to say, that the conditions under which they were formed must have been almost the same all over the area now occupied by them.

Consequently from the examination and study of the south-western portion of this area it is possible to get a very good notion of the formation and elevation of this vast tract of mountain country —the highest in Southern Africa.

The rocks which go to build up this mountainous area belong to the uppermost division of the Karroo formation, to the Stormberg series, so-called from its typical development in that part of the country where the beds were first mapped in detail. The Stormberg beds cover an immense area in South Africa: namely, in the Cape Colony (Eastern Province and Native Territories) about 10,500 square miles; in Basutoland (the whole of that country) 10,300 square miles; but their extent in the Orange River Colony and over Natal can only be guessed at roughly.

The Stormberg series is divided up as follows, in descending order:—

4. Volcanic beds.
3. Cave sandstone.
2. Red beds.
1. Molteno beds.

The characters and extent of each of these divisions will have to be briefly described, in order to ascertain the conditions under which they were laid down.

II.—THE SEDIMENTARY ROCKS.

The lowest of these, the Molteno beds, have been so named by reason of their typical development around the town of Molteno, and are of great importance economically, inasmuch as they contain the only workable seams of coal known to occur in the Cape Colony.

The Molteno beds consist of bands of sandstone (varying from fine-grained greyish varieties to coarse gritty quartzose or felspathic grits), and dark shales and mudstones usually weathering to pale blue, yellow, or buff, with occasional seams of black carbonaceous shale and coal.

The remains of plants are abundant in the softer beds, and their examination has led to the assigning of the Molteno beds to the stage known in Europe as the Rhætic.

The formation crops out over the flattish ground at the foot of the Drakensberg, and on the western border of Basutoland, but in the Stormberg area the beds form fairly high ground, owing to their general easterly dip.

In the west the Molteno beds have a thickness of from 1,000 to 1,200 feet, but this increases in the Transkei, so that in Xalanga and Elliot they are about 1,800 feet thick.

How they vary in Maclear, and still further to the north-east, is not yet known.

In marked contrast to the Molteno beds comes the overlying division known as the Red beds; for in the latter the rocks are usually highly-coloured. Beds of pale yellow and white sandstones are numerous; but the softer rocks are sandstones, shales, mudstones, and clays of red or purple colour, while green, bluish or yellow tints are also common. The colouring is more intense in the upper part of the Red beds, especially where the rocks are freshly exposed. Fossil remains are not very abundant; vegetable life is represented almost solely by fragments of silicified wood; animal life by the bones of carnivorous dinosaurs, such as *Euskelesaurus* and *Massospondylus*.

The thickness of the Red beds is variable in different parts of this area. At the Barkly Pass, leading over the Drakensberg from Elliot to Barkly East, it is 1,600 feet; but both to east and west it thins considerably; and in the Stormberg area, and on the west side of Basutoland, it is usually from 600 to 800 feet in thickness.

The Red beds crop out along the slopes of the Drakensberg from Indwe as far north-east, at least, as Van Reenen's Pass near Harrismith.

Over the greater part of Wodehouse, and around Jamestown, the high ground is formed of Red beds, the highest ridges being capped with Cave sandstone and Volcanic beds.

From Lady Grey this division extends into Basutoland, and is exposed in the valley of the Orange River for many miles above Palmietfontein.

We can follow it along the flanks of the mountains of the Basutoland border from Kornet Spruit past Mafeteng, Maseru, Thlotse, to the head of the Caledon River.

The high ground to the north of Ficksburg, and from Bethlehem to Harrismith, is, according to the accounts of G. W. Stow, built up of Red beds and Cave sandstone.

The Cave sandstone, the uppermost division of the sedimentary rocks, is fine-grained and white or yellow in colour; pink and pale blue varieties are occasionally met with, and the rock is often of considerable thickness. The sandstone is usually unbedded throughout the greater portion of its thickness; towards the top it is often laminated. False-bedding is, however, common, and is sometimes developed on an extensive scale. The sandstone is commonly very soft, and under the action of atmospheric agencies weathers most unevenly. Portions of it are easily eroded and form smooth rounded slopes and domes, often grass-covered, while the rest of the rock projects in rugged crags and pinnacles, often with the most fantastic of outlines.

Such scenery is graphically recorded by Dunn as occurring on the farms Wonder Hoek and Klipfontein in the Stormberg area, between Molteno and Jamestown.

To the north-west of Elliot the Cave sandstone in places forms vertical cliffs as much as half a mile in length and 500 feet in height, while due north of the town there are numbers of peculiar pyramids and pinnacles crowning a spur of the Drakensberg. Mr. Schwarz has noted a similar type of scenery in Griqualand East.

The unequal weathering of the sandstone often gives rise to large caves, some capable of sheltering several thousand sheep, and hence the name first given to the formation by E. J. Dunn. In many of the caves there are still drawings and paintings done by the Bushmen who formerly inhabited this area, and whose crude weapons and implements are occasionally picked up. The Cave sandstone is usually remarkably uniform in character throughout this area, but in parts of Wodehouse and Barkly East the central portion of the bed is pale bluish in colour and very fine grained, passing almost into a mudstone.

Under the microscope the sandstone is seen to consist of abundant angular to sub-angular grains of quartz, fairly uniform in size, set in a pale, almost colourless, ground mass. There are also fragments of orthoclase, plagioclase, and microcline felspar, flakes of white mica, and grains of zircon, epidote, and tourmaline in small quantity.

It has been suggested that the Cave sandstone is, in part, of volcanic origin, containing much finely-disintegrated material ejected by the volcanoes, and derived from granitic and metamorphic rocks deep down below the surface of the earth.

Against such a view I must, however, protest, for there seems to be no evidence to support it. Everything, in fact, points to the Cave sandstone being a normal type of sediment.

The thickness of the Cave sandstone is variable. The maximum yet known in the Colony is 800 feet, occurring at the Barkly Pass; but in Natal Mr. Churchill records a similar value. This makes it, I believe, the thickest unbedded stratum of sandstone known to geologists.

More commonly it varies from 200 feet to 400 feet, but in a number of places the sandstone is either very thin or entirely unrepresented, the Volcanic rocks resting directly upon the Red beds.

Fossils occur but sparingly in the Cave sandstone, and are chiefly reptilian in character. The age of the Red beds and Cave sandstone is probably the same as the Lias (Lower Jurassic) of Europe.

Having now placed on record the characters of the sedimentary rocks of the Stormberg series, we have next to consider the source of the sediments which go to form them and the conditions under which the materials were deposited.

III.—PHYSICAL CONDITIONS DURING SEDIMENTATION.

It is well known that all the sedimentary rocks of the Karroo system were laid down in a large lake or inland sea whose boundaries are as yet known only approximately.

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That this vast body of water was not salt is indicated by the absence of marine fossils, the few mollusca known being lamellibranchs such as *Palæomutela.* The presence of *Estheriæ* in both the Beaufort and Stormberg series points, perhaps, to brackish rather than purely fresh-water conditions.

That the lake was shallow throughout most of the period of its existence is proved by the presence of false-bedding in the sandstones, and by ripple-marks, rain-prints, sun-cracks, and worm-burrows. Local erosion of the soft beds, with the deposition upon them of coarser arenaceous material—contemporaneous erosion, as it is termed—is met with occasionally, and points to the existence of strong currents.

Now, as sediment was carried down into the Karroo lake, the latter would tend to become silted up. The great thickness of the Karroo rocks—many thousands of feet—shows that the lake continued to receive sediment during an immense period of time, and yet the depth must have remained much the same all through. This shows either that the water level was continually being raised by the sediment deposited on the bottom of the lake, or else there must have been a general subsidence of the area occupied by the Karroo lake, due either to weighting of the earth's crust by the sediments laid down upon it or owing to elevation of the crust in a neighbouring area. Probably both factors have combined to cause the depression.

Now, we find that during the formation of the Upper Karroo rocks there were two tracts in which folding and elevation were going on, within the area of the Karroo lake.*

The first of these tracts is the mountainous country around the Cederberg, to the west of the Karroo, elevated by the continuation of earth movements dating back to pre-Karroo times.

The second area lies along the south coast of the Colony, and the mountain ranges produced form the Zwarteberg, Langeberg, Zuurberg, &c. The beds are intensely folded in this area, but northwards these folds die out rapidly, and in the central portion of the Karroo the rocks are hardly affected by them.

The earth-movements which produced these second set of folds have been named by Mr. A. W. Rogers "the Zwartberg movements," and, according to him, "took place some time between the period of deposition of the upper part of the Beaufort series and the close of the Stormberg series." † It is apparent that during the period mentioned the folding reached its maximum, but the earth-movements must have continued, though with less intensity, during a considerably longer period.

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* *Vide* Reports of the Geological Commission, 1896–1903. Cape Town.

† A. W. Rogers, "The Geological History of the Gouritz River System." Trans., South African Philosophical Society, vol. xiv., p. 376, 1903.

The ridge of pre-Karroo rocks, which extends from Zululand to a point on the coast a little north of Port St. John's, is one along which hardly any folding has taken place. But it is very probable that the rocks which are exposed along it formed part of an old surface in pre-Karroo times which extended south-eastwards, and formed again during the Stormberg period a land surface, now buried beneath the waters of the Indian Ocean. The forces which affected the level of this old land surface are probably distinct from those which caused the foldings in the Zwartebergen.

There is much probability that during the deposition of the rocks of the upper portion of the Karroo system earth-movements affected the earth's crust on three sides, namely, west, south, and south-east, though not necessarily at exactly the same time, or with the same degree of intensity.

It is probable that at the commencement of the deposition of the Molteno beds, these foldings had already profoundly modified the old land surface, and consequently affected the position of the shore line of the Karroo lake. We find that there is a sudden change in the character of the beds both palæontologically and lithologically. The various labyrinthodonts and dinosaurs, whose remains are so abundant in the uppermost portion of the Beaufort series, are practically unrepresented in the Molteno beds. The brilliant colouring of the softer rocks of the Beaufort series is entirely absent in the higher division, and instead we meet with grey, blue, or black mudstones and shales, with occasional coal seams.

The fossils which are found in these beds are of ferns such as *Thinnfeldia*, *Tæniopteris*, and *Callipteridium*, cycads such as *Phoenicopsis* and *Schizoneura*, while fragments of silicified wood belonging to coniferous trees are abundant in some of the sandstones.

That the land surface on which these plants flourished lay considerably to the south and south-east of the Drakensberg is shown by inferences drawn from the following considerations: (*a*) The condition of the plant remains; (*b*) the development of the beds in this area; (*c*) the petrographical characters of the beds; each of which will have to be considered in turn.

(*a*) It has commonly been stated that the Molteno beds must have been formed close in shore on account of the very perfect state of preservation of the fern leaves, but let us see what evidence can be obtained from the beds in this area.

If we choose a locality such as Jamestown, where well-preserved fern fossils can be obtained, we find that the Molteno beds extend round about it for a distance of fifty miles at least, and similar plants can be got at Molteno, Herschel, Engcobo, &c.

That is to say, plants occur in the beds over an area with a diameter of one hundred miles, and yet specimens from the centre are in as good condition as those obtained from points on the circumference. Clearly, then, by being drifted an additional distance of fifty miles the plants were not appreciably injured. An examination of the sandstone beds, on the other hand, shows that the plant remains are nearly always more or less fragmentary, and that, too, in any part of the area. Consequently the condition of the fossil ferns in the beds gives us no help in estimating the distance they must have drifted before they were ultimately entombed in the sediment.

These plants, together with other vegetable material, have gone to form the coal seams of the Molteno beds. By some geologists each coal seam is supposed to represent an old land surface, or, more properly speaking, a swampy tract of land where the vegetation grew and was afterwards buried.

I am, however, a strong supporter of the theory of the subaqueous origin of the Stormberg coals vigorously upheld by Green and Galloway. According to this view, the coal seams do not indicate former land surfaces, but simply unusual phases of sedimentation, during which finely-divided carbonaceous material was deposited along with a varying amount of finely-divided matter of detrital origin. In this way we get all gradations from mudstone and shale to coal, while sometimes we get very rapid alternations of coaly and shaly material, giving the coal a finely laminated structure.

The carbonaceous material was deposited in fairly shallow water, in which the currents were often strong. This explains their local character, for the soft, pulpy vegetable matter would be easily carried away by currents. At Indwe these currents have been laden with coarse sediment, and in places several feet of coal and shale have been removed and their place taken by the gritty material. False-bedding is common in these grits, and now and then little lenticular seams of coal and shale occur, sometimes wavy and contorted.

It is significant that the most important coal seams are found to the south and south-east of the Stormberg area, namely, Molteno, Indwe, Engcobo, Maclear, &c., while in Aliwal North, Herschel, and Rouxville coals are infrequent, thin, and of very poor quality.

(*b*) *The development of the beds.* From the description already given of the various members of the Stormberg series, it will be seen that, although each varies considerably in thickness, the same variation affects them all simultaneously. The maximum thickness of the sedimentary strata is attained in the eastern part of Elliot, namely, 4,200 feet, made up as follows: Molteno beds, 1,800 feet; Red beds, 1,600 feet; and Cave sandstone, 800 feet. In Molteno and Aliwal North the thickness is only 2,000 feet, and sometimes less, proportioned thus: 1,200 feet, 600 feet, and 200 feet. In Matatiele, according to Mr. Schwarz, the two upper members together do not, as a rule, exceed a few hundred feet.

The conclusions to be drawn from this great thickening of the beds along a line drawn from north-west to south-east is that the old shore line lay somewhere to the south and south-east. As will be seen from the map, Elliot is situated so that sediment could arrive at it from the south-west, south, and south-east, hence the exceptional thickness of the beds thereabouts.

(*c*) *The petrographical characters of the beds.* A petrographical examination of the sandstones in the Molteno beds shows that the material has been derived chiefly from the disintegration of quartzite, granite, and metamorphic rocks. The fine-grained sandstones are built up principally of rounded and angular grains of clear quartz, together with fragments of milk-white or blackish quartz, orthoclase and microcline felspar, garnet, zircon, apatite, tourmaline, and flakes of mica.

The coarser sandstones are sometimes very quartzose but at other times contain large angular fragments of felspar in a very fresh condition, so that the rock may be termed an arkose. At no horizon lower down in the Karroo system are similar beds met with.

The coarse, gritty sandstones occasionally become conglomeratic, the pebbles consisting principally of vein-quartz and of quartzite; by the farmer such beds are called "banket," and believed to be auriferous.

A peculiar feature in connection with the Molteno beds is the occurrence in them of smooth rounded or oval pebbles usually a few inches across, but ranging up to boulders two feet in length. These pebbles are, as a rule, scattered most irregularly through some of the sandstones, for example, in the bed which immediately overlies the coal at Indwe. In the Molteno Division these pebbles are so numerous as to form beds of conglomerate up to a few feet in thickness, and on Romansfontein and Hassiesfontein one of these beds can be followed for several miles.* It occurs a little above a seam of coal, and in some places rests directly upon the coal without the latter being in any way disturbed.

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* E. J. Dunn, "Report on the Stormberg Coalfields," p. 17, Cape Town, 1878.

At Molteno, Molyneux has recorded pebbles and boulders embedded in the actual coal itself.

The pebbles are almost entirely of white, brownish, or glassy quartzite like that of the Witteberg and Table Mountain series, but hard white slatey rocks are also represented.

The distribution of these pebbles, too, indicates their original source. They are most abundant to the west of Molteno; at Indwe, Cala, and Engcobo they occur rather scattered; south of Burghersdorp they are fairly common; in Aliwal North and Herschel very rare; while Mr. Schwarz has not noticed them in Matatiele.

The pebbles are found principally in the Molteno beds, but sometimes, though not commonly, in the lower part of the Red beds.

The pebbles show very fine, smooth surfaces, and resemble very much the rolled material found along the shores of a lake or along a coast-line. To take a near example, we have the same thing at Hout's Bay, where the well-rounded boulders are derived from the Table Mountain sandstone.

The difficulty, of course, lies in accounting satisfactorily for their transport, for it is evident that a current with a strength sufficient to move one of these boulders would entirely prevent the deposition of any finely-divided sediment. The quartzites must have been carried a great distance, for the nearest outcrop of the Witteberg series at the present day is about 130 miles due south, at Grahamstown.

The pebbles might have been brought across embedded in sand and clay adhering to the roots of trees, but perhaps a more reasonable explanation is that they have been transported by ice.

It is well known that in cold regions the beach material becomes incorporated with the ice formed along the shore line.

In the spring such a floe of ice would be carried away by currents and the foreign material included in its mass deposited during the process of melting.

In this manner the pebbles might have been dropped and so become embedded in soft shale and even in the coal itself. If this is the correct explanation, the old shore line at this period would have been formed of Witteberg quartzites somewhere to the south of Grahamstown, and the Table Mountain sandstone cropping out further south still would not necessarily be a contributor to the conglomerate beds.

In Matatiele, as will be seen from the map, the nearest outcrop of quartzite is in East Pondoland; but it is probable that during Stormberg times the Dwyka conglomerate entirely covered up the Table

Mountain series there. The Witteberg series is also apparently absent. This would explain the absence of quartzite pebbles in the Molteno beds in that part of Griqualand East.

We see now that at the commencement of the Molteno stage the supply of comminuted ferruginous material was cut off and replaced by the detritus of a land surface built up of granite, metamorphic rocks, and quartzites.

The action of the Zwartberg movements caused an elevation of the strata in the south and an extensive land surface was produced. The lower members of the Karroo system, if present, were rapidly removed by denudation, the rocks of the Cape system cut into, and the pre-Cape rocks—slates, metamorphic rocks, and granite—laid bare. It is possible that at this time, too, the extreme west of the Karroo was dry land and contributed to the forming of the Stormberg series.

At the close of the Molteno stage there must have been considerable changes in the land surface due both to denudation and to the continuance of the Zwartberg movements. Granite and quartzite still contribute largely to the derived rocks, but the abundant red and purple sandstones, shales, and mudstones testify to the denudation of an area in which ferruginous rocks, such as jaspers and magnetite slates and schists were well represented. We have, in fact, a return to the conditions which existed in pre-Stormberg times, and instead of finding ferns and cycads as fossils in the rocks, the remains are once more those of dinosaurian reptiles.

The Zwartberg movements continued to modify the land surface, and at the summit of the Red beds red-coloured sediment ceased to be deposited with marked abruptness. Instead, we get the fine-grained arenaceous Cave sandstone, whitish or yellowish in colour, sometimes with a pinkish or pale bluish tint.

The change usually takes place within a few feet in vertical range, but sometimes the dividing line is remarkably distinct. Occasionally towards the base of the sandstone there are lenticular beds of reddish clay and mudstone, but of small extent laterally.

The mineralogical composition of the sandstone, described previously in this paper, shows that the rock has been derived principally from quartzite and granite. The absence of marked bedding in the sandstone is due to the great uniformity of the material; specimens from near Molteno are identical with samples from Elliot, Matatiele, or even Harrismith.

There is plenty of evidence to show that the Karroo lake was very shallow, and in many places there must have been extensive sandy flats, sometimes hardly covered by the water.

In the Cave sandstone on Lelie Kloof, near Jamestown, Dunn records the occurrence of slabs, showing sun-cracks and the tracks of (?) crustaceans. At Morija, in Basutoland, according to Mr. Dornan, of that place, there are numerous footprints of dinosaurs in the sandstone, while he states that such are also found at Harrismith. The discovery of crocodilian remains in the sandstone in Barkly East is also significant.

The occurrence in a few places of thin bands of blue-black shale in the sandstone, full of remains of *estheriæ* and other crustaceans, perhaps indicates, as has been mentioned already, the slightly brackish character of the water. The extensive false bedding often met with in the lower portion of the sandstone shows that there were strong currents in the lake; later on, these ceased, as is indicated by the uniform bedding in the upper portion.

While the lake silted up there were small movements in the earth's crust which heralded the great volcanic eruptions of the Drakensberg. In many places the bed of the lake rose above tide level and a portion of the material was eroded, and sometimes the entire bed of sandstone has thus disappeared. At several places earthquakes fractured the strata, and some of the gashes produced were filled in with soft sand, now forming irregular dykes through the Red beds.

Such were the physical conditions just before the commencement of the volcanic outbursts; a great *vlei*—if one may so term it—several hundred miles in diameter, with brackish water covering a sandy bottom. This *vlei* was studded with muddy flats and islets, over which wandered dinosaurs and crocodiles in search of their prey.

IV.—Volcanic Activity in the Drakensberg.

The sedimentary rocks of the Drakensberg are penetrated by a large number of volcanic necks, from which immense quantities of lava, and occasionally volcanic ash, were erupted. Since Mr. Schwarz's discovery of nineteen necks in Griqualand East, over eighty additional vents have been recorded within a radius of about fifty miles of Barkly East.

This by no means represents the total number occurring in that area, for there must be many vents which are buried beneath great piles of lavas and not yet exposed by denudation.

When it is considered that the hundred volcanoes now known are all situated within an area of a little over 5,000 square miles, we get an idea of the immense number which still remain to be discovered in the Colony, Basutoland, and elsewhere. The volcanic necks are not arranged along certain lines, but are distributed in a most irregular manner. They mostly occur in groups, but are sometimes isolated from one another. In their lack of any definite arrangement they resemble the Carboniferous volcanoes of Central Scotland, the Permian vents of Fifeshire, those of the Eifel, the Swabian Alps, and the Auvergne.

There is no necessity to give a description of any of these volcanoes, and we may proceed to an account of the material which issued from them.

According to all the descriptions available, the Volcanic beds in Griqualand East, Basutoland, and Natal, are almost entirely basic lavas.

In Barkly East and west of Jamestown beds of sandstone and volcanic ash occur in the midst of the igneous flows. The volcanic ash may pass over insensibly into a sandstone by the addition of sedimentary material, or *vice versâ;* the thickness of such beds is very variable, but may reach as much as 350 feet. The usual type of ash is a reddish or bluish-green rock, with fragments of shale sandstone and grit derived from the underlying Stormberg beds, boulders of Cape and pre-Cape rocks, and portions of lava from minute lapilli to great masses several feet across. These beds of fragmental and siliceous material afford a vast amount of minute information with regard to the volcanic history of the areas in which they occur. Where the lavas alone occur the information to be gleaned from them is very meagre.

One of the most peculiar types of igneous rock is that known as pipe-amygdaloid, the lava being penetrated by long, thin branching pipes, about the thickness of a lead pencil, now filled with secondary minerals. These pipes are found only at the base of a lava flow where it rests on a bed either of lava, ash, or sandstone, and never in the centre or upper part of the flow. There can be no doubt that the pipes were produced by steam generated below the lava as it flowed over a wet surface.

If the molten material were very mobile the steam bubbles would ascend rapidly to the top of the mass, but if it were very viscid long elongated bubbles would be formed, which would ascend very slowly. Two or more of these bubbles would tend to coalesce as they expanded upwards, and hence the branching of the vesicles. In many cases the movement of the lava is shown by the bending of the pipes so that they are inclined forward in the direction of motion. In a few examples the deflection from the vertical was found to be as much as sixty degrees. The common length of a pipe is from four to six inches, but some were occasionally met with of double that length. The immense number of horizons at which the pipe-amygdaloid occurs in this area—sometimes over a dozen are present in a vertical distance of a few hundred feet—shows that the lava usually flowed over a wet surface. When we add to this the fact that we get numerous thin beds of usually well-stratified sandstone and ash between the lavas, it will be seen that the evidence for the sub-aqueous eruption of the lavas is very strong. In the Barkly East Division the history of volcanic activity can be made out with considerable detail, whereas in other areas we find only a succession of lava flows from which nothing much can be learnt.

We have seen that, at the close of Cave sandstone times, there existed a vast shallow lake or sea, with a sandy bottom.

The first evidence of the pent-up energy below the crust of the earth is shown by faulting in the rocks on the eastern border of Wodehouse. These faults must have been formed by earthquakes which heralded the volcanic outbursts.

The strata bulged up in places and the currents rapidly removed the obstructions, so that occasionally the whole of the Cave sandstone was carried away before the first eruptions occurred.

Thin, irregular lava flows interbedded in the Cave sandstone indicate the birth of the earliest of the Drakensberg volcanoes. They were immediately followed by others, and lava streams flowed over the bed of the lake, while ash and volcanic bombs were occasionally ejected.

Along the Kraai River valley the bed of the lake subsided in two separate areas, and lava was rapidly accumulated. Whenever an eruption diminished in vigour sediment was deposited, and a bed of sandstone formed. In many cases the upper surface of the underlying lava was cracked and fissured, and into the spaces silt introduced itself. Some of these veins of sandstone have been baked to quartzite, showing that the central portion of the lava flow was still at a high temperature. Ash and masses of molten material were flung into the air from the craters, and became embedded in the still soft sediment. Many of these masses of lava are several feet across, and must have been in the molten state when they fell into the soft mud, for their lower surfaces show rows of pipe amygdules arranged normally to their bases. Some of these blocks have been ejected a distance of certainly over half a mile from the nearest known crater.

Such were the preliminary volcanic outbursts in the area, but they were apparently dwarfed by the eruptions which followed. Scores of volcanoes came into action apparently almost simultaneously, great holes being blown through the strata by the explosive action of highly-heated gases. In some cases no lava issued from the vent, and the fragments of the strata fell back into the funnel and blocked it up, so that what we now find exposed is a mass of agglomerate built up almost entirely of masses of sandstone and shale, set in a groundmass of finely pulverised gritty material.

In other cases the explosions were followed by ejections of volcanic ash, bombs, and molten material, which spread for miles around each vent. These explosive eruptions produced the bed of ash, often of considerable thickness, which is met with over such a large area in Barkly East, and which usually rests directly upon the Cave sandstone.

Lavas poured forth from the volcanoes, and many of the smaller craters were overwhelmed by the material and choked after a brief existence. The more active volcanoes continued their outpourings, though beds of ashy material show that there were occasional lulls during which finely divided material only was being thrown out.

As we get higher up in the midst of the lavas we find that these intercalations of sandstone and ash become less frequent, and finally disappear, and the only outbursts were of molten rock. Probably, too, the supply of sediment was cut off from this area either by the drawing off of the waters of the lake, by the barrier formed through the accumulation of the lavas, or by the sinking of the old land surface to the south. One after another the volcanoes exhausted their energy, and were buried beneath the ejections of their more active neighbours until even the eruptions of these in turn became feeble, and the volcanoes finally became extinct. The amount of volcanic material must have been enormous; in many places there are over 3,000 feet of rock exposed. At Ongeluk's Nek, in Griqualand East, Mr. Schwarz[*] has noted a thickness of 4,000 feet, while, according to Mr. Churchill,[†] this amount is much exceeded in Natal.

The lofty cliffs of lavas which occur right on the present escarpment, together with the regularity of the lava flows, indicate that the volcanic rocks must have originally extended far to the south-east beyond the present known south-eastern limit of the volcanic necks.

We have no idea of the interval of time during which the eruptions continued, but it may have been of long duration, perhaps extending well into Jurassic times.

[*] Ann. Rept. Geol. Commission for 1902, p. 45.

[†] "Notes on the Geology of the Drakensberg, Natal." Trans. South African Philosophical Society, vol. x., part 3, 1898.

It is interesting to note that in India at this same period the lava-flows of the Rajmahal Hills were being poured out. It is interesting again because all over the globe the Jurassic epoch was one during which volcanic activity seems to have been remarkably rare.

V.—LATER HISTORY OF THE AREA.

No sooner had the piling up of the lavas ceased than denudation began to remove the uppermost layers, and small rivers coursed over the plains of volcanic rock.

It is possible that the mass of lavas was thicker in the centre, thinning away at the sides, so that the formation of the watershed might date from this time. On the other hand, it is equally possible that the watershed was produced at a somewhat later stage.

Of the physical conditions in the western portion of the Karroo we can only hazard a guess, but it is possible that there was already in that part of the country a well-established river system.

The folding, which was still going on in the south, gradually extended northwards, and the land surface was thrown into a series of nearly parallel troughs and ridges trending nearly east-north-east.

The flow of water was naturally along these troughs, and hence the direction of the courses of the Orange River, Kraai River, and the head waters of the Tsomo, Tsitsa, and Kenigha Rivers.

Apparently, just after these gentle foldings had affected the rocks, the Karroo Dolerites were intruded, invading and penetrating the strata from Natal to Namaqualand, so that dykes of dolerite are even found cutting through the lava-flows.

It has been suggested that the effect of the dolerite intrusions would be to cause a heating of the strata so that the central portion of the Cape Colony would tend to bulge upwards, but I think that the elevation was produced by the forces which continued to affect the level of the land long after the intrusion of the dolerites, even down to comparatively recent times.

After these gigantic intrusions had ceased the strata were affected by a series of gentle north and south folds which, to a certain extent, modified the existing river-systems, but those rivers which had already excavated deep valleys were unaffected by the changes of level. The courses of the Indwe, Tsomo, Bashee, and Kenigha Rivers, the Sterk Spruit (Barkly East), Kornet Spruit and Waschbank River are thus accounted for.

Owing to the cross-folding, we get rivers flowing along the dips produced by the compounding of these two sets of folds; for example, the various tributaries of the Kraai River, the Telle River, &c. By the excavation of the rocks the rivers formed valleys whose floors became gradually flatter and flatter as the grade of the river-beds became smaller and smaller. As the vertical erosion became less and less the rivers eroded laterally, and finally wide plains were produced across which the rivers flowed sluggishly in numerous serpentine loops and bends.

These plains of river erosion were formed in a period during which the level of the earth's crust was but slightly affected by earth-movements, so that the rivers were able to cut down to their base-level. If a period of elevation followed, the downward erosive action of the rivers was resumed, and the loops and bends of the streams were perpetuated in deep gorges. When the elevation ceased a second and lower plain of river erosion, or peneplain as it is termed, would be formed.

These peneplains are very well developed in this area, more especially in Barkly East. The highest plateau is found at an altitude of a little over 8,000 feet above sea-level, around the village of Rhodes, and extends to the present escarpment of the Drakensberg, overlooking Maclear. On the north, some peaks along the Witteberg Range indicate the higher ground which bounded the peneplain in that direction. It is evident that the plateau once must have extended further to the south and south-east until it reached higher ground forming the watershed, and separating the drainage area of the Kraai River from that of the Tsitsa and Tina Rivers.

How far away that may have been situated from the present watershed we have no idea; it was probably many miles, but all the beds have since been removed by denudation. An elevation of a couple of thousand feet followed, and the rivers cut down and formed a peneplain at an altitude of about 6,000 feet above sea-level. This was a most extensive plateau; much of it still remains in the Kraai River valley, and there is no doubt that it extended away to Dordrecht and Jamestown. A continuation of this peneplain is found along the Orange River, in Basutoland.

On the south-east side of the Drakensberg the high ground around Cala, Engcobo, and Bazeia is probably a remnant of a peneplain at about the same altitude, but the country has been greatly denuded.

A second period of upheaval followed, and a peneplain at an altitude of between 4,500 and 5,000 feet formed, which covers an extensive area in Albert, Aliwal North, Herschel, and the Orange River Colony. Beds of river gravels are common at many points over this vast area. Even then the crust of the earth was not in equilibrium, for the rising continued, and at the present day the Orange River and its tributaries flow in deep, narrow, winding gorges at a depth of several hundreds of feet below the general surface of the country, and a peneplain is in gradual process of formation.

Owing to our present lack of knowledge concerning the belt of country between the Drakensberg and the Indian Ocean, it is impossible to bring forward any information with regard to the number of peneplains which are present in that area. It is known, however, that the country rises in the form of a series of steps from the coast inland. With each elevation the rivers tended to cut back into the plain which they had just formed, and the crest of the Drakensberg has thus retreated considerably.

In this way a very precipitous face would be formed, and, as Mr. Schwarz has suggested, the production of the escarpment would be greatly aided by a heavier rainfall on the sea-ward face. It must be noted that in Herschel and on the west side of Basutoland the mountains rise quite as abruptly and to the same height as in the Transkei, and I think that the most important factors in the production of the long escarpment were, firstly, a large number of nearly parallel streams leading from the mountains to the ocean; and, secondly, their much shorter courses.

In cutting their way back the rivers on the south-east met with no serious obstruction until they began to lay bare the great chain of dolerite laccolites, extending north-eastwards from Engcobo through Mount Ayliff. The igneous material proved rather difficult to erode, and hence the rivers have cut comparatively narrow gorges in the dolerite instead of wide valleys. As the escarpment retreated softer rocks were again met with to the north-west, and readily eroded.

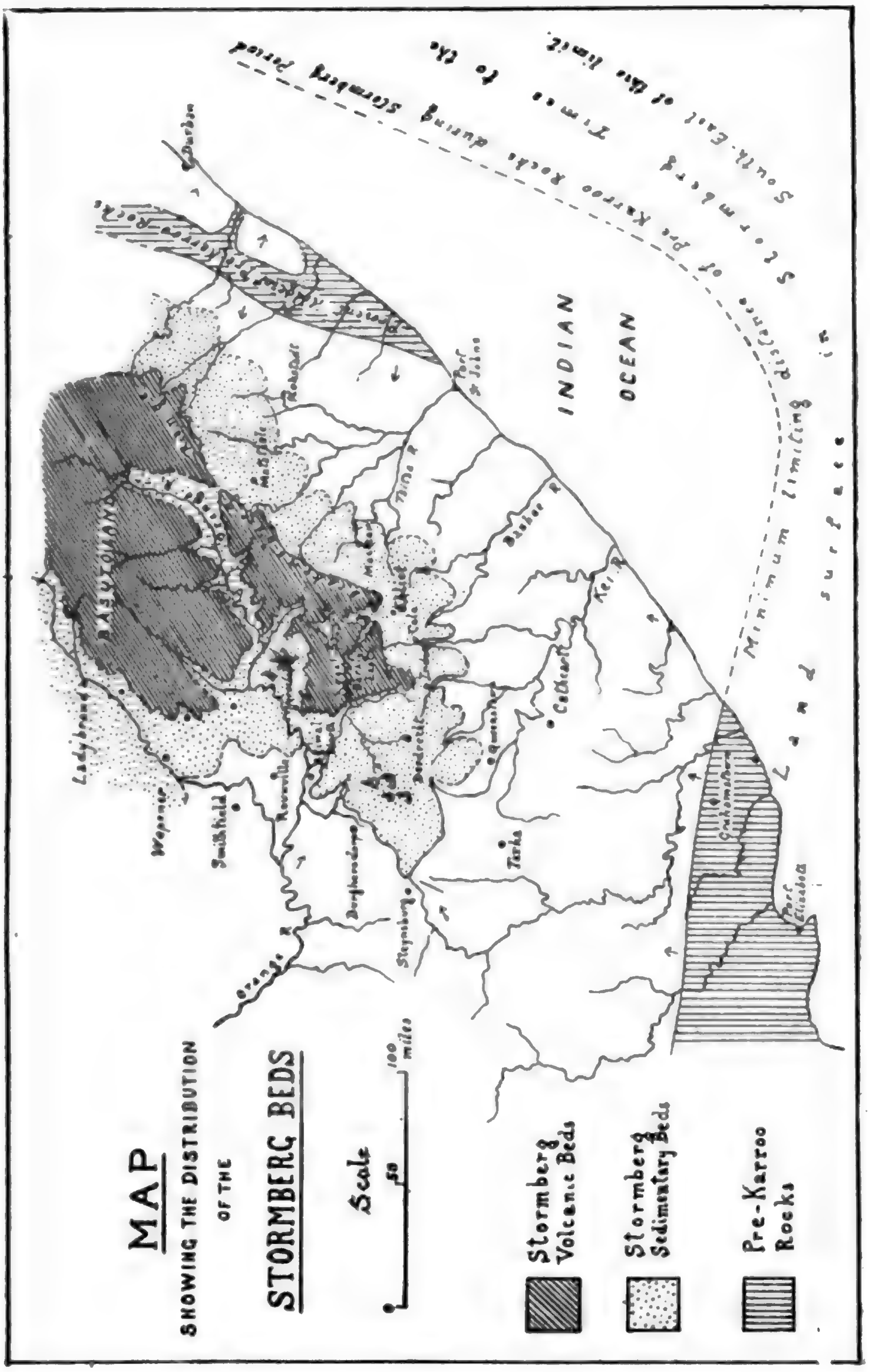
Hence the line of laccolites is now marked by a tract of high-lying ground separated from the present escarpment by a narrow belt of much lower-lying country. At one time this long escarpment must have extended westwards, probably beyond Steynsburg, but the tributaries of the Orange River have been very active in removing material, and the watershed across Molteno and Wodehouse is now very low; in fact, just south of Dordrecht it is quite a flattish tract, with isolated ridges and hills.

What the Stormberg and Holle Spruits have accomplished in the west the Long Kloof River and Sterk Spruit are doing further east; and at the Barkly Pass there is a great gap where the Volcanic beds have been removed, and from which the Cave sandstone is being rapidly eroded. Similarly, in Matatiele, the pass at N'Quatsha's

Nek is on Cave sandstone flanked on either side by piles of lavas.

In time to come great tracts will thus be separated from the great mountain area of Basutoland, and will then be denuded so as to resemble the country between Molteno and Jamestown.

The consideration of the submergence of the old land surface beneath the waters of the Indian Ocean while the Drakensberg area was being elevated, is one which cannot be discussed in this paper. It involves the history of the earth-movements which affected the southern portion of the Cape Colony, and postulates a knowledge of the conditions under which the Uitenhage series of the Colony and the Cretaceous rocks of Pondoland and Zululand were formed.


MAP
SHOWING THE DISTRIBUTION
OF THE
STORMBERG BEDS
Scale
50
100 miles
Stormberg Volcanic Beds
Stormberg Sedimentary Beds
Pre-Karroo Rocks
INDIAN OCEAN
Minimum limiting distance of Pre Karroo Rocks during Stormberg Period
Land surface in Stormberg Times to the South-East of this limit.
BASUTOLAND
Durban
Port St Johns
Kokstad
Matatiele
Maclear
Elliot
Cala
Bashee R
Kei R
Cathcart
Queenstown
Tarka
Dordrecht
Aliwal
Rouxville
Burghersdorp
Steynsburg
Orange R.
Smithfield
Wepener
Ladybrand
Grahamstown
Port Elizabeth

ON THE AFFINITIES OF *TRITYLODON*.

By R. Broom, M.D.

(Read November 30, 1904.)

Tritylodon longævus was described in 1884 by Owen* from an imperfect skull submitted to him by Dr. Exton, the Curator of the Bloemfontein Museum. The specimen is stated to have been found at "Thaba-chou, Basutoland." Unfortunately there is some doubt about this locality, as no place of this name is to be found on any of the recent maps of Basutoland. There is a mountain south of Morija called Thaba-tsueu, which may be the locality. There is, of course, the well-known locality in the Orange River Colony, Thaba'Nchu, but this is hardly likely to be the spot, as Dr. Exton, who submitted the specimen to Owen, was present at the meeting of the Geological Society at which the paper describing the specimen was read, and is not likely to have allowed the statement that the specimen came from Basutoland to have passed without correction, if wrong. It is further highly probable that the name of the locality was given by Dr. Exton, who, of course, would be well aware that Thaba 'Nchu was not part of Basutoland in 1883. The importance of the determination of the locality lies in the fact that the whole of Basutoland belongs to the Stormberg age, and is of much more recent date than the Upper Beaufort beds of Aliwal North and Burghersdorp, which have yielded the Theriodonts. While the latter are believed to be Upper Triassic, the former are most probably Lower Jurassic.

Owen described the specimen as the remains of a Mammal, and pointed out a large number of features which seemed to confirm this view, among others the striking resemblance of the teeth to those of *Stereognathus*; and this view has had the support of a number of palæontologists, including Lydekker [*] and Seeley,[†] the latter of whom expressed the opinion in 1887 that *Tritylodon* was a "Bunotheroid Rodent."

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* R. Owen, "On the Skull and Dentition of a Triassic Mammal (*Tritylodon longævus*, Owen) from South Africa." Q.J.G.S., vol. xl., 1884, p. 146.

In 1894 Seeley,[‡] as the result mainly of his discovery of Theriodonts with flattened molar teeth, gave up his earlier view and came to the conclusion that "*Tritylodon* was a Reptile," but admitted the possibility of its belonging to "a group of animals intermediate between Mammals and Theriodonts." In 1895 he definitely placed *Tritylodon* in the "Gomphodontia." As, in 1898, Seeley [§] expressed the opinion that the Theriodonts are not the ancestors of the Mammals, we may assume that he has abandoned the view of 1894 that *Tritylodon* may possibly belong to a group intermediate between Mammals and Theriodonts.

Let us look at the evidences which Seeley brings forward in support of the view that *Tritylodon* is a Theriodont and not a Mammal.

In the first place the orbit is said to have been closed behind as in Theriodonts. On this point the specimen gives very little evidence. Owen considered that the orbit was probably incomplete behind, and until a more perfect specimen is discovered it will be impossible to definitely settle the point. As, however, many Mammals have the orbit closed behind by bone the point is not of very much importance. A much more important point is whether *Tritylodon* had a distinct postfrontal or postorbital bone. By Owen the pair of bones behind the frontals are believed to be the parietals; by Seeley they are looked upon as the inner parts of the postfrontals. If they are postfrontals or rather postorbitals they are unlike the postorbitals of the known Theriodonts. In *Gomphognathus* and *Trirachodon* the Theriodonts with which Seeley compares *Tritylodon*, the frontals pass well back between the inner parts of the postorbitals, but in *Tritylodon* the frontals are prevented from passing backwards by the median union of the two bones behind. The bones thus resemble rather mammalian parietals than Theriodont postorbitals. Even, however, should the bones be ultimately proved to be postorbitals, it must be remembered that postorbitals occur in *Ornithorhynchus*.

In the second place Seeley points out that in Theriodonts the snout has a bulbous appearance, owing to the widening of the maxillary bones by the roots of the large canines, while in *Tritylodon* there is a widening of the snout by the roots of the teeth which have been regarded as the incisors. The facts that the front teeth are separated by an interspace; that the incisor roots extend into the maxillary bones; and that in Theriodonts evidences are sometimes apparently found of a successional canine behind the large canine led Seeley to doubt whether the large front teeth in *Tritylodon* "may not be regarded as canines comparable to the canines of Theriodonts, rather than as incisors comparable to the incisor teeth of Mammals like Rodents." The occurrence of an interspace between the front incisors is met with in a number of Mammals, and the fact of the incisor roots extending into the maxillary bone is of such common occurrence in Mammals that it may be said to be the almost invariable rule if the incisors are large. As in no Reptile, Theriodont or other, are large incisor teeth known which pass back into the maxillary bone, the occurrence of them in *Tritylodon* is rather to be regarded as an evidence of the mammalian affinity of the genus. The swelling of the snout, caused by the teeth roots, does not seem to be a character of much importance; but there is no difficulty in pointing out a number of Mammals in which it occurs—both carnivorous and herbivorous.

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[*] R. Lydekker, Cat. Fossil Mammals, Brit. Mus.

[†] H. G. Seeley, "On Parts of the Skeleton of a Mammal, &c." Phil. Trans., 1888, p. 141.

[‡] Ibid., "The Origin of Mammals." Int. Cong. Zool., Cambridge, 1898.

[§] Ibid., "The Reputed Mammals from the Karroo Formation of Cape Colony." Phil. Trans., 1895, p. 1025.

Another of Seeley's arguments in favour of the Theriodont affinity, is that "the nares are terminal in *Tritylodon* and in Theriodonts"; but as the nares are also terminal in Mammals this fact proves nothing. It will be pointed out, however, presently, that the nares in *Tritylodon* are very different from those of the Theriodonts.

Seeley finds another Theriodont character in the posterior nares. He says: "The posterior nares are conditioned as in Theriodonts, opening between the hinder molar teeth. This character is not mammalian. . . . As far as the evidence goes the posterior nares are Theriodont." It is difficult to understand how the conclusion was arrived at that the opening of the posterior nares between the hinder molar teeth is not a mammalian character. Among Rodents—the very Mammals with which Seeley formerly placed *Tritylodon*—it is such a common character that it might be regarded as the rule. But the character is by no means confined to Rodents. It is met with in forms as different in other respects as *Petrogale*, *Procavia*, *Palæomastodon*, *Equus*, *Ovis*, *Coryphodon*, *Uintatherium*, and *Galeopithecus*. In fact, the list of Mammals in which the internal nares open between the posterior molars can be extended to almost any required length, and Mammals fulfilling the condition can be found in most of the orders. It will thus be seen that the position of the posterior nares in *Tritylodon* is similar to that seen in a large number of Mammals. On the other hand, no Theriodont is known in which the posterior nares open between the hinder molar teeth. Whatever evidence, therefore, is afforded by the position of the posterior nares is in favour of *Tritylodon* being a Mammal rather than a Theriodont.

One character observed by Seeley—the presence of a distinct prefrontal bone—is of much more importance than any of those previously mentioned in determining the affinities of *Tritylodon.* In 1894 he could state, "The presence of a prefrontal bone is a reptilian character unknown among Mammals." But, in 1896, he discovered that a prefrontal bone exists also in *Ornithorhynchus*, a discovery that has since been confirmed by van Bemmelen.* So that, though the presence of a prefrontal bone would remove *Tritylodon* from the Eutheria or the Metatheria, it would not remove it from the Prototheria.

On the other hand, we have the very important mammalian characters pointed out by Owen. Of these, perhaps the most important is the structure of the molar teeth. The molars have rows of well-developed cusps, and have distinct roots. There is no known Theriodont with either the one or the other, and both characters are found in the molars of known Mammals. There is one important point in connection with the molars, the bearing of which has not, I think, been fully recognised. In 1898 Osborn† pointed out that in "typical Multituberculates like *Tritylodon*" "the dental series are parallel with each other as an adaptation to the forward and backward motion of the jaw." This conclusion is fully justified. Even if we knew nothing of such animals as *Meniscoëssus* and *Cimolomys*, we could be quite certain from the arrangement of the upper molar cusps that the lower molars must have had the cusps also arranged in rows, and further that the lower molars must have worked against the upper with an antero-posterior movement as in Rodents. To admit of such movement the articulation must have been of the mammalian type, as no antero-posterior movement would be possible in a form having the Theriodont type of articulation; and as the different type of articulation is the only fundamental point of difference between the Theriodont and the Mammal, it follows that *Tritylodon* must have been a Mammal.

The condition of the anterior nares in *Tritylodon* is another point of interest. In all known Theriodonts in which the parts are satisfactorily preserved the premaxillary bones send upwards a median process which meets the nasals and divides the nares. In

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* J. F. van Bemmelen, "Der Schädelbau der Monotremen." Zool. Forschungsreisen in Austr. u.d. Malay Archipel., 1901.

† H. F. Osborn, "The Origin of the Mammalia." Amer. Nat., May, 1898.

Tritylodon this process is absent, or rather represented by a mere rudiment. In no adult Mammal are the nares ever divided, as in the Theriodonts. In the young Monotremes, however, the median process of the premaxillaries is still seen, and in certain young Marsupials (*e.g.*, *Macropus*) there is a slight trace of it, very similar to that seen in *Tritylodon*. So that any evidence derived from the condition of the anterior nares is also in favour of *Tritylodon* being a Mammal rather than a Theriodont.

Taking all points into consideration, there seems to be no good reason for placing *Tritylodon* with the Theriodonts, and many reasons for leaving it where Owen placed it—among the Mammals. So far as can be made out, the affinities seem to be more with the Monotremes than with the higher forms. It is unfortunate that to-day the only living Prototherians are the extremely degenerate *Ornithorhynchus* and *Echidna*, but it is not improbable that the Multituberculates of Jurassic and Cretaceous rocks may have been Prototherians, and the presence of prefrontal bones would seem to favour this view.

ADDENDUM.

Since the above was written I have received the following information from the Rev. S. S. Dornan, of Morija:—"With reference to your note *re* specimen from Thaba-chou, I know of no locality of that name, or at least of that spelling. I suspect that Thaba-tsueu (pronounced Tāba-tswayou) is the correct locality, but the difficulty is that there are several mountains of the same name in Basutoland. There is a Thaba-tsueu about three hours (18 miles) from here, a prominent mountain, but I do not know whether any fossils have been found there or not, though so far as I know the strata are the same as here."

It seems likely that the specimen was collected by some Free Stater who took part in the Basuto war, 1879–81.

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SOME RESULTS OF OBSERVATIONS MADE WITH A BLACK BULB THERMOMETER *IN VACUO.*

BY J. R. SUTTON, M.A., F.R.Met.S.

(Read February 22, 1905.)

The object of this investigation was chiefly to ascertain some of the effects of various meteorological influences upon the indications of a black bulb thermometer *in vacuo*. No attempt is made here to discuss the suitability of the instrument for purposes of physical research, beyond expressing the opinion that it does seem to have been underrated in many quarters from the time of Sir John Herschel downwards.* The investigation was prompted as much by what has been urged against it by English physicists and others, as by the inconclusive nature of the supposed results obtained by some of those who approve of it.

The black bulb thermometers used here have been, by preference, of the ordinary pattern without a test gauge, and have given fairly comparable readings. During 1903 an instrument with a test gauge was used, but the glass sheath was defective, and the readings averaged with fair consistency 7° too low. A correction has been applied to the 1903 readings on this account. The readings are in every case for an altitude of 4 feet above a grass lawn.

Mean and extreme values for the seven years 1897–1903 are given in Table I. It appears from this that the highest mean temperature in the sun comes near midsummer, the lowest near midwinter; the mean monthly values ranging from 118°·8 in June and July to 153°·3 in December; the difference between these two giving an annual variation some 9° greater than that of the mean monthly maxima in the shade. Readings exceeding 170° have been noted once or twice in the summer, and as much as 130° in the winter. Therefore the summer extreme may be fully 17° higher than the summer mean, while the winter extreme is not likely to exceed the winter mean by more than 12°. The greatest difference between the mean and extreme readings is found in October, and is nearly 25°. The mean for the year is nearly 138°.

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* See, *e.g.*, J. Herschel, "Meteorology," p. 12, 1862. *Q. J. R. Met. S.*, July 1886, p. 193. W. M. Davis, "Elementary Meteorology," p. 61. J. Eliot, *Indian Met. Mem.*, xii., p. 32. The late G. M. Whipple used to read the black bulb thermometer at X., and the shade maximum at XXII., and got differences which suggested that the black bulb thermometer should be set aside in favour of the Sunshine Recorder!

TABLE I.

MONTHLY MEAN VALUES OF SOLAR RADIATION TEMPERATURES.

	Maxima in Sun.				Maxima in Shade.	Difference between Max. in Sun and Shade.	
	Mean Observed.	Extreme Observed.	Mean Computed.	C–O.	C–O.	Mean.	Extreme.
	°	°	°	°	°	°	°
January	151·0	170·5	152·9	+ 1·9	+ 0·3	62·4	77·2
February	152·7	168·5	149·8	– 2·9	+ 0·7	63·0	74·7
March	143·8	159·0	142·8	– 1·0	– 0·8	60·2	75·1
April	135·3	148·7	133·2	– 2·1	+ 0·1	57·8	69·1
May	125·7	139·6	123·6	– 2·1	+ 0·1	55·0	68·9
June........	118·8	131·1	118·8	0·0	0·0	53·9	66·8
July	118·8	130·2	121·9	+ 3·1	+ 1·5	53·1	67·6
August......	127·3	144·1	128·8	+ 1·5	+ 1·3	55·5	73·1
September ..	136·3	156·1	138·5	+ 2·3	+ 1·7	58·1	79·1
October	141·6	166·3	146·9	+ 5·3	+ 2·1	60·0	75·3
November ..	148·8	168·8	151·6	+ 2·8	+ 1·4	62·4	73·5
December ..	153·3	170·5	153·3	0·0	0·0	63·0	74·5
Year........	137·8	170·5				58·7	79·1

The differences between the maxima in sun and shade increase with fair uniformity as the temperature rises, that is from winter to summer. From which it follows that the temperature in the sun increases faster than the temperature in the shade.

It is interesting to compare the observed monthly mean maxima in the sun, one with the other, by means of some formula. Now, in a previous paper it had been shown that the maxima in the shade at Kimberley may be approximately represented by the formula—

$$T = AS^2 \cos Z + B$$

where on any day

T is the maximum temperature required;

S the sun's apparent semi-diameter in seconds of arc (S^2 being therefore the relative magnitude of the sun's apparent area)

Z the sun's zenith distance;

A and B being constants equal respectively to 73°·4 and 22°·8.*

---

* J. R. Sutton, "Some Pressure and Temperature Results," *Trans. S.A. Phil. Soc.*, vol. xi., pt. 4, p. 252.

Using the same formula, and assuming that the turning-points come at the same time in sun and shade, we get, as expressing the solar maxima,

$$A = 86^{\circ}\cdot 2;\ B = 71^{\circ}\cdot 3.$$

The monthly means obtained by means of these constants are given in Table I., and also the differences C—O between those computed and those observed.

It is evident from the signs of the values in the C—O column that there is some lagging of the temperature, the maxima not falling so fast in the autumn, nor rising so quickly in the spring, as they would if the correspondence between the sun's altitude and the temperature were exact. From a climatological point of view this is important. The greatest differences, minus and plus, are in February and October respectively, these months as it happens embracing the annual maximum of cloud at noon, the October cloud being largely stratiform and the February cloud largely cumulus. Table I. gives further, for purposes of comparison, the differences between the computed and observed monthly mean maxima in the shade. In character they agree very well with—albeit they are smaller than—the corresponding solar differences.

Table II. gives comparative meteorological elements for the four years 1900–1903. It gives monthly mean values of—

(1) The mean maximum in the sun;
(2) The mean difference between the maxima in sun and shade;
(3) The mean percentage of cloud for the hours XI. and XIV.;
(4) The mean dew-point, and
(5) Humidity at Noon.

A cursory glance is sufficient to show that there is not any very obvious relation between the solar temperature and either the state of the sky or the hygrometric state of the air, beyond the fact that in a rough way the amount of cloud is least, and the temperature of the dew-point lowest, in the winter when the black bulb temperatures are lowest and the difference of maxima least. There is nothing at any rate to suggest or to confirm certain previous results. For example, Stow claimed that "solar radiation" (*i.e.*, the difference between the temperatures of sun and shade) is greatest when the vapour tension is less than the average.* His argument and conclusion seem to have been that the greater the quantity of moisture in the air, the greater will be the absorption of the sun's heat by the air, and therefore the temperature of the air will be raised at the expense of the heat which would otherwise have reached the black bulb. The evidence of Table II., so far as it goes, says just the opposite. Later on we shall have reason to suspect that the effect which Stow thought to be due to water vapour may be partly due to other causes; and also, incidentally, that a mere tabulation of monthly averages cannot unravel the tangle of influences that go to the making of a black-bulb temperature.

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* Rev. F. W. Stow, "On the Absorption of the Sun's Heat Rays by the Vapours of the Atmosphere," *Q. J. Met. S.*, January, 1875, p. 241. The excess reading of a thermometer in the sun above one in the shade as a measure of "solar radiation" is at least as old as the time of Lambert, say the middle of the eighteenth century.

TABLE II.

COMPARATIVE METEOROLOGICAL ELEMENTS FOR THE FOUR YEARS 1900–1903.

	Temperature in the Sun.	Difference between Maxima in Sun and Shade.	Cloud XI. and XIV.	Dew-point at Noon.	Humidity at Noon.
	°	°	%	°	%
January	152·0	61·8	36	49·3	30·7
February	153·0	63·2	41	53·1	35·0
March	143·7	60·3	37	52·1	42·0
April	135·2	58·3	32	49·2	43·9
May	127·1	54·6	20	40·8	37·6
June	118·4	53·7	22	37·2	43·0
July	119·1	53·0	20	36·9	41·0
August	126·9	55·6	17	37·2	35·0
September	135·4	58·2	34	40·4	32·8
October	134·1	60·1	36	42·4	31·6
November............	148·3	62·2	30	42·9	27·3
December	151·5	62·1	40	50·0	31·8
Year	137·7	58·6	30	44·3	36·0

Again, according to an obscure paper by J. Park Harrison, H. von Schlagintweit arrived at the conclusion that the maximum isolation came on days of great relative humidity.* This may be so in India; if we could trust Table II. we should say that it probably is not so in South Africa. For we get both high and low solar temperatures and temperature-differences when the relative humidity is high; and also high and low humidities when the temperatures and temperature-differences are high. In particular we get a mean monthly temperature 10°·6 above, and a temperature-difference 3°·6 above the annual means when the monthly mean humidity is lowest; and the lowest mean maximum, and nearly the lowest temperature-difference with almost the highest relative humidity.*

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* J. P. Harrison, "Note on Solar Radiation in Relation to Cloud and Vapour" *Q. J. Met. S.*, October, 1875, p. 455. The author does not clearly distinguish between relative and absolute humidity, nor define whether by insolation he means the maximum temperature as registered by the black bulb *in vacuo* or its excess over the maximum temperature in the shade.

It seems necessary, then, to compare the various elements in some more effective way. First of all, to show the tendency of a variation in the cloudiness of the sky, Table III. has been constructed. It gives for each percentage of cloud—

(1) The number of observations;

(2) The annual mean maximum temperatures in the sun and shade, and the difference of maxima;

(3) The annual mean values of the dew-point and relative humidity at noon.

The mark ... signifies that the sky is cloudless, 0 per cent. that there is some cloud but less in quantity than 5 per cent. of the whole sky. In a great number of instances this last includes clouds lying low down on the horizon.

TABLE III.

THE ELEMENTS ARRANGED IN A SEQUENCE OF CLOUD PERCENTAGES.

Cloud %.	No. of Observations.	Annual Mean Dew-point at Noon.	Annual Mean Relative Humidity at Noon.	Annual Mean Maxima in the Sun.	Annual Mean Maxima in the Shade.	Annual Difference of Maxima.
		°	%	°	°	°
...	424	40	30	136	79	57
0	114	42	31	138	81	57
10	119	44	34	137	80	57
20	117	44	34	138	79	59
30	119	45	34	140	82	58
40	110	46	36	141	80	61
50	105	45	35	142	80	62
60	100	46	39	141	79	62
70	78	47	41	139	77	62
80	77	47	41	139	77	62
90	46	49	52	132	76	56
100	51	50	61	113	69	54

We see from this Table that on the whole the temperature of the dew-point, and the relative humidity, both increase with the increase of cloud. The temperature in the sun, however, is at its highest when the sky is half-clouded. This seems to indicate, what is otherwise not improbable, that when the sky is more than half covered the clouds are as likely to shut off the solar heat as to impede radiation from the thermometer. Under certain circumstances, moreover, clouds may reflect heat to the thermometer. The temperature in the shade seems not to be so much influenced by the amount of cloud. It falls off a little when the percentage of cloud exceeds 60 per cent., and notably so when the sky is quite overcast. Perhaps on the whole the greatest cloud effect upon the temperature of the lower air is somewhere about 40 per cent. The difference of maxima between sun and shade, however, goes on increasing up to a cloudiness of 70 per cent. or 80 per cent. The explanation of this fact seems to be that a clouded sky accelerates the time of maximum shade temperature, changing it from the normal at 3 p.m. when the sky is clear, to 1 p.m., or earlier, when there is much cloud. Thus the shade temperature will not go on increasing for so long a time under a very clouded sky; consequently the rise, after the time when the black bulb has attained its maximum, will be less in magnitude. There are rare occasions, in cloudy weather, when the maxima in the sun occur late in the afternoon.

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* R. T. Smith could not find any directly traceable connection between aqueous vapour tension and solar radiation. But he only discussed monthly averages. See *Q. J. R. Met. S.*, July, 1886, p. 188.

TABLE IV.

THE ELEMENTS ARRANGED IN A SEQUENCE OF CLOUD PERCENTAGES.

Cloud %.	Maxima in the Sun.			Difference of Maxima.			Dew-point at Noon.			Relative Humidity at Noon.		
	Jan. to April.	May to Aug.	Sept. to Dec.	Jan. to April.	May to Aug.	Sept. to Dec.	Jan. to April.	May to Aug.	Sept. to Dec.	Jan. to April.	May to Aug.	Sept. to Dec.
	°	°	°	°	°	°	°	°	°	%	%	%
...	144	124	141	58	54	59	43	37	40	28	36	26
0	145	125	144	58	54	59	47	38	43	30	37	27
10	145	124	142	59	54	59	50	39	43	35	38	28
20	147	123	145	60	55	60	50	38	43	35	39	28
30	148	125	146	61	54	60	51	39	45	36	39	29
40	150	125	147	63	56	63	52	41	44	37	41	30
50	150	125	149	64	56	64	53	37	45	37	38	31
60	150	125	147	65	57	64	54	40	45	41	44	32
70	148	122	147	65	57	64	54	42	45	42	49	31
80	149	120	148	66	56	65	55	37	47	45	45	33
90	137	122	136	59	53	57	56	42	50	60	46	50
100	126	88	125	52	31	50	58	41	53	67	62	55

Table IV. gives a subdivision of the elements of Table III. into periods of four months each. The most striking fact is that during the period May–August the variation of cloud appears to have very little influence upon the behaviour of the black bulb, and that the maximum at 50 per cent. shown by Table III. is due entirely to the readings during the eight months September–April. By comparing the solar maxima with the difference of maxima between sun and shade, we elicit the curious circumstance that from January to April the temperature in the shade is practically unaffected by any quantity of cloud below 50 per cent.; whereas during the period May–August the shade temperature shows a tendency to fall as the amount of cloud becomes greater, and actually to rise somewhat during September–December as the amount of cloud increases from zero to 50 per cent.

Seeing that the temperature of the dew-point, and the relative humidity, both rise as the amount of cloud increases, in each of the three terms of the year, the explanation is not by any means self-evident.

For the purpose of getting a better idea of the effect of moisture upon the temperatures as shown by a black bulb thermometer *in vacuo*, the observations under an absolutely clear sky have been separated from the rest and considered alone. Some such process seems to be wanted because for small amounts of cloud the actual places of the clouds in the sky will be of the first importance. According to both Stow and Park Harrison clouds near the sun increase "radiation," whereas clouds near the horizon can have but little influence. Thus a mere cloud percentage may be misleading. A further important advantage of a consideration of clear skies only is that the maxima in sun and shade fall at very nearly definite hours, and are therefore much more readily comparable. Sequences of temperature under clear skies have been made for dew-points and humidities at noon in ascending order of magnitude, after the algebraic addition of a monthly constant which raises the monthly mean temperatures to the mean of the year.

Table V. gives the temperature variations corresponding to assigned dew-points. It should be explained that the dew-point 28° includes really all dew-points under 30°; the dew-point 33° all dew-points from 31° to 35°; the dew-point 38° all dew-points from 36° to 40°; and so on; all over 50° being classed with the dew-point 53°.

In this Table the values corresponding to a dew-point of 53° are somewhat doubtful, partly because they are obtained from a very few observations; but the other columns are better. Our impression from the Table is that Stow's result is correct (even if his way of getting it is not quite satisfactory), and that the difference of maxima between sun and shade is high when the dew-point is low, the one rising as the other falls. Now this result is brought about by the circumstance that both the sun and shade temperatures rise as the dew-point rises, but that the latter rises almost twice as fast as the former. If we suppose the law of the Table between dew-points of 28° and 48° to continue, this would make the temperatures in sun and shade equal at something less than 200°, while the corresponding dew-point would be about 270°. In general a dew-point higher than the temperature is, of course, out of the question; but it is curious that the mean of the three, when the first two coincide, should not greatly differ from the boiling-point. This would mean that an atmosphere of aqueous vapour at barometric pressure would absorb the whole of the solar heat. At the absolute zero, by the same law, the difference of maxima would be 325° F., the temperature in the shade being −459°, and in the sun −134°. No such supposition, however, is admissible, considering the nature of the evidence and the irregularity of the values in the Table.*

TABLE V.

ANNUAL MEAN TEMPERATURES CORRESPONDING TO ASSIGNED DEW-POINTS AT NOON.

Dew-points =	28°	33°	38°	43°	48°	53°
	°	°	°	°	°	°
Max. Temp. in the Sun........	131	184	135	137	136	137
Max. Temp. in the Shade......	71	76	78	80	81	79
Difference of Maxima..........	60	58	57	57	55	58
Humidity %..................	30	29	29	32	38	38

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* Prof. Langley concluded from his observations on Mt. Whitney that in the absence of any atmosphere the temperature of the earth's surface would rise to −373° F. under direct sunshine. ("Researches on Solar Heat," p. 123.) But Prof. Poynting shows that according to Kurlbaum's determination of the amount of energy issuing from a fully radiating surface at any temperature, a black sphere 1 sq. cm. in cross-section placed in full sunshine at the earth's distance from the sun would attain a surface temperature of 70° F.; while a flat surface facing the sun would reach 140° F. The earth's surface would probably be 20° less, because it reflects some of the heat. (*Nature*, Sept. 22, 1904.) It will be remembered that Sir John Herschel thought that the surface of the full moon must necessarily be very much heated, "possibly to a degree much exceeding that of boiling water" ("Outlines of Astronomy," 1851, p. 261). R. A. Proctor held the same view, and quoted with approval Lord Rosse's result that the diurnal range of temperature on the moon amounts to fully 500° F. ("Old and New Astronomy," 1892, p. 523). C. A. Young, however, remarks that "there is no air-blanket at the moon's surface

But we have to remember that the values given in Table V. are complicated by the radiation of dark heat from the bulb of the thermometer. The fact that the relative humidity falls on the whole (see the last line of the Table) as the dew-point falls bears directly upon this fact. For if the rate of radiation of dark heat is governed by moisture at all, whether it depends upon the relative or the absolute humidity, or both together, it is certain that it will be greater for the lower temperatures of the Table than for the higher (apart from the greater difference between the temperature of the black bulb and that of the surrounding air). The maxima in the sun are hence relatively lower in the drier air than they would be if the radiation of dark heat were independent of the moisture present. That is, it is not inconceivable that the difference of maxima would increase faster as the temperatures decreased if the radiation of dark heat were constant.

In Table VI. the matter is examined in another way by arranging the maxima in sun and shade, under clear skies, in the order not of dew-point but of relative humidity. According to this arrangement the maxima in the sun and shade both fall as the humidity increases; between ratios of 18 per cent. and 48 per cent. the latter falls 16° while the former falls 12°: consequently the "radiation" increases as the humidity increases. That is to say, a damp air seems at first sight to have the same influence upon the action of the black bulb as air with a small quantity of moisture. And the result is the more remarkable because, as it happens in Table VI., the dew-point shows a disposition to rise, albeit not very rapidly, as the ratio of humidity rises. In fact, if Table VI. stood alone the conclusion to be drawn would seem to be exactly the opposite to that of Stow mentioned above; but at the same time to perhaps conform to that of H. von Schlagintweit.

to prevent it from losing heat as fast as it receives it"; but he does not explain how this can be, and yet that the maximum temperature is attained three days after full moon ("General Astronomy," 1888, p. 162). A favourite argument with those who hold that no part of the moon's surface is ever very warm is that on the top of our highest mountains, where of course the air is rare, there is perpetual snow. Wherefore, by analogy, the lunar surface must be colder still. But it is not an analogy at all. The air at high levels is cold because it intercepts little of the solar radiation. The snow does not melt because it reflects, instead of absorbing, a very great proportion of the incident heat. As for the supposed important fact that in the lunar radiations there is a considerable quantity of heat having a wave-length greater than that of the heat radiated from a block of ice, it may be suggested that it comes, in large measure, from high lunar latitudes. Some remarks by E. Nevill (Neison) on this subject in his great work, "The Moon," 1876, p. 37 *et. seq.*, are worth attention.

When the relative humidity is greater than 48 per cent. the difference of maxima seems inclined to decrease. The effect is certainly not very definite; but such as it is it agrees with Abney and Festing's result that, as the air in cooling approaches the point of saturation it begins to exert a considerable absorptive action upon the solar heat.* As it happens, a good number of higher humidity ratios included under 58 per cent. (which actually stands in place of "greater than 55 per cent."), were near the point of saturation.

TABLE VI.

ANNUAL MEAN TEMPERATURES CORRESPONDING TO RATIOS OF RELATIVE HUMIDITY AT NOON.

Relative Humidity =	18%	23%	28%	33%	38%	43%	48%	53%	58%
	°	°	°	°	°	°	°	°	°
Max. Temp. in the Sun ..	141	139	137	135	133	132	129	131	128
Max. Temp. in the Shade..	86	83	80	77	76	73	70	74	70
Difference of Maxima	55	56	57	58	57	59	59	57	58
Dew-point	39	39	39	40	42	42	41	43	44

It is not easy to see how Tables V. and VI. are to be reconciled; and more especially so, because if we approximately reduce the values of Table V. to a constant relative humidity by means of Table VI., and reduce the values of Tables VI. to a constant dew-point by means of Table V., no essential change is effected in the differences of maxima beyond making the sequences a little more regular. The following, however, seem to be fair inferences:—

The decrease in the difference of maxima with increasing dew-point shown in Table V. is caused by the greater absorption by the air of the heat from the direct rays of the sun. This absorption may be considered for the present as a function of the quantity of moisture present, and not of the humid state of the air; for if a humid air absorb more solar heat than a drier air (say, *e.g.*, a cold air absorb more than a warm air while the dew-point remains constant), then the difference of maxima in Table VI. should decrease, instead of increasing, as the percentage of humidity increases. Radiation from the black bulb does not impair the general validity of these considerations; for whether this vary with the *quantity* of moisture or not, it is hardly likely, *ceteris paribus*, to be more rapid when the dew-point is high than when it is low. Therefore, for the lower dew-points of Table V. the readings of the black bulb may be less, they cannot well be greater, than they would have been if there were not any radiation of dark heat. Therefore in any case the difference of maxima should increase as the dew-point falls. So far this accords with the conclusion formulated by Prof. Langley twenty years ago, that "observations taken at different seasons of the year, at different hours of the day, or at different altitudes above sea-level, all point to the same conclusion, namely, that there is a large absorption of solar radiation which depends upon and increases with the prevalence of atmospheric moisture." *

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* Quoted in Hann's "Handbook of Climatology" (Ward's Edition), p. 119. I have not present access to the original.

If our conclusion be justified that the absorption of the sun's heat is almost or quite independent of the humidity of the air, it follows that the variation of the differences of maxima as shown by Table VI. actually represents the variation of the radiation of dark heat from the black bulb, and that on this account alone the black bulb will read 4° or so lower in very dry air than in air half saturated with aqueous vapour.

But this difficulty is created: If it be acknowledged as a fact that the sun emits rays of all orders of refrangibility, and that every absorbing particle in the earth's atmosphere converts the energy it receives into rays of a lower order, it would seem that a humid air should have the same effect upon some parts of the extreme infra-red of the solar spectrum as it has upon the rays of terrestrial dark heat. Therefore direct solar rays of this class would be largely detained in the middle reaches of the atmosphere because the high relative humidity must retard their free passage. Consequently these rays could never be easily discovered, unless at great altitudes, by direct observation of the sun.

I have not been able to ascertain whether the behaviour of the black bulb thermometer *in vacuo* under a perfectly cloudless sky has been previously discussed. Certainly there are not many places in the world where the conditions are sufficiently favourable to make such discussion profitable. So that I am not able to tell whether Tables V. and VI. are in agreement with earlier work. But if the suggestions in the three preceding paragraphs are correctly deduced it seems that the solar heat rays capable of selective absorption are divisible into two classes: one being absorbable by aqueous vapour, the absorption of the other depending upon the humidity of the space containing the aqueous vapour. There is, however, an alternative and probably a better view, namely, that the solar radiation is absorbable in proportion to the absolute humidity alone (leaving out of account, of course, the case when the condensation limit is approached); but that once absorbed it is emitted in rays of lower order and different character, absorbable in proportion to the relative humidity alone. This latter view agrees better with the fact that both reflected solar heat and radiated dark heat reach the earth from the moon.[*]

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* S. P. Langley, in his classical "Researches on Solar Heat," p. 189. Since the text above was written I have seen an even more definite statement by F. E. Fowle, Jr., which is worth quoting in full: "The selective absorption of water vapour within the range of densities observed seems to depend only on the amount of the absorbent present, and is well expressed by Bouguer's formula. In other words, the absorption produced by a given quantity of water in the form of vapour is the same whether the path is great through a small density or *vice versâ*."—*Smithsonian Mis. Coll.*, 1904, vol. ii., p. 11.

It is interesting to compare the average of the monthly values of the absolute maximum temperature in the sun and the average of the monthly values of the greatest difference of maxima in sun and shade with other meteorological elements of the same days. In Table VII. the first line gives the mean of the absolute maxima, while the second line gives the mean of the greatest difference of maxima between sun and shade.

TABLE VII.

AVERAGE VALUES OF (1) ALL THE HIGHEST TEMPERATURES IN THE SUN IN EACH MONTH; AND OF (2) ALL THE GREATEST DIFFERENCES OF TEMPERATURE BETWEEN SUN AND SHADE; COMPARED WITH OTHER METEOROLOGICAL ELEMENTS DURING THREE YEARS.

Maxima in the Sun.	Maxima in the Shade.	Difference of Maxima.	Cloud.	Relative Humidity.	Dew-point.	Dust.	Thunder and Lightning.	Hoar Frost or Dew at VIII.
°	°	°	%	%	°	Times.	Times.	Times.
149·3	85·7	63·6	41	28	44·7	12	13	7
144·0	75·1	68·9	54	41	45·5	3	11	7

The average black-bulb temperature in the second line is so high because it occasionally happens that the greatest difference of maxima in a given month goes with the absolute maximum temperature in the sun. The dew-point differs but little in the two cases, but the amount of cloud and the relative humidity each differ by 13 per cent. High temperatures and great temperature-differences are preceded by morning dew or frost not more than once in five times, while thunder and lightning follow, in the afternoon or evening, once in three times. Dust has evidently more connection with high temperatures than with great temperature differences.

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[*] For some interesting remarks bearing upon this see W. M. Davis on "The Absorption of Terrestrial Radiation by the Atmosphere," in *Science*, October 11, 1895; also the Earl of Rosse, "On the Radiation of Heat from the Moon," *Phil. Trans.*, 1873.

Scott has remarked that the highest observed temperature in the sun of which he had heard was 215° at Leh, and not infrequently, in Tibet, observations had been taken ranging above the boiling-point of water to the height of the place.* It seems to me to be exceedingly doubtful if such high temperatures as these could possibly be registered by a black bulb *in vacuo* exposed in the orthodox way. By suitable artifice they may, of course, be obtained. Thus Blanford mentions that Dr. Cayley succeeded in making water boil at Leh, 11,500 feet above sea-level, by exposing it to the sun in a small bottle blackened on the outside and placed inside an empty quinine phial to protect it from the wind.† Again, by placing an open black bulb thermometer in a wooden box lined with velvet and covered with a sheet of plate glass, it is possible to obtain a temperature of 200° to 250° in the sun. De Saussure, with a wooden box lined with blackened cork and covered with three sheets of glass, obtained 190°.‡ Langley, on Mount Whitney, in September, 1881, with his "hot box" obtained 236°.§ J. Herschel using a similar apparatus obtained 248° at midsummer, at the Cape, and even cooked eggs, fruit, meat, &c., with it; he remarks that by suitable precaution a temperature approaching to ignition might readily be commanded.|| All these cases, however, represent accumulated, not instantaneous, solar radiation. The highest black-bulb temperature obtained by Dr. Scully in Western Tibet during the summer of 1875, at any altitude exceeding 10,000 feet, was 147°·5. And even this, together with some others of 130° to 135°, at the same high altitudes, "are probably attributable to the radiation received from the rocky sides of the valleys." ¶

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* R. H. Scott, *Q. J. Met. S.*, April, 1873, p. 171; also the same author's "Elementary Meteorology," 1893, p. 56.

† H. Blanford, "Climates and Weather of India," p. 2. The boiling-point at this altitude is about 192°.

‡ See J. Forbes, "Transparency of the Atmosphere," *Phil. Trans.*, 1842.

§ S. P. Langley, "Researches on Solar Heat," p. 167.

|| J. Herschel, "Results of Observations at the Cape of Good Hope," Appendix C., p. 444.

¶ H. Blanford, *Indian Met. Memoirs*, vol. i., p. 220.

TABLE VIII.

SOME COMPARATIVE STATISTICS OF SOLAR RADIATION.

Station.	Altitude in Feet.	Cloud at Noon.	Relative Humidity at Noon.	Dew-point at Noon.	Difference of Maxima.			
					Observed.	Corrected to Cloud = 30 %.	Corrected to Humidity = 36 %.	Corrected to Dew-point = 44°.
		%	%	°	°	°	°	°
Kimberley	3,950	30	36	44·3	58·6	58·6	58·6	58·6
Leh......	11,540	54	51	31·6	63·4	61·4	57·6	55·8
Chakrata..	7,050	48	52	45·6	67·9	65·9	63·2	63·6
Ranikhet..	6,070	44	47	48·6	57·5	56·0	54·2	55·3
Dehra....	2,230	38	55	60·8	54·9	53·9	50·7	54·9
Roorkee ..	890	29	47	59·7	53·3	53·3	51·5	55·4
Bareilly ..	570	31	50	62·4	52·0	52·0	41·7	54·4
Adelaide..	140	51	46	50·2	57·7	55·7	54·0	55·6
Cordoba ..	1,440	47	51	51·3	55·3	53·6	51·1	52·9

The Indian values in the first six columns of Table VIII. are extracted chiefly from a discussion of the meteorology of the North-West Himalaya, by the late S. A. Hill.* Values for Kenilworth (Kimberley), Adelaide, and Cordoba are inserted for comparison. The quantities for the different places are not strictly comparable. At Cordoba the mean difference of maxima only applies to clear days, since readings of the black bulb are not taken on cloudy days. The amount of cloud at the Indian stations is the mean of all the observations at whatever time of the day they are made, and this may differ somewhat from the true noon values. At Kenilworth the amount of cloud is the mean of observations at XI. and XIV. The humidity percentages for the Indian stations are also the means of all the observations. I have deducted 15 per cent. from each to get the approximate noon percentages. The humidity percentages and dew-points for Adelaide are derived from the maximum values of dry and wet bulbs, which are not usually attained at noon, nor do they necessarily occur simultaneously. I have left the Indian dew-points untouched, not having materials wherewith to correct them for daily range.

Indian meteorologists were never very friendly to the black bulb thermometer. (Why do they use it at all?) Hill commented as follows: "If the air were absolutely diathermanous the altitude of the sun above the horizon and the vertical thickness of the atmosphere above the place of observation should have no effect upon the temperature differences, which should therefore be the same for all the stations and for every month of the year. But the air having some absorbing power the differences should be greatest when there is least air for the sun's rays to pass through; that is to say, at the highest stations and in the summer months. Up to Chakrata the excess temperature of the solar thermometer does increase with a fair degree of regularity, but it appears to be less at Leh than at Chakrata, contrary to all theory. There is also no regular increase apparent in the heating power of the sun as the season changes from winter to summer. The truth is that the indications of the black bulb thermometer are affected by so many disturbing causes that after all possible corrections they are of little or no value for inter-comparison; though with the same thermometer at the same place and under absolutely constant conditions of exposure the figures for one year may be to some extent comparable with those of another." The probable error in this criticism is, of course, that any sort of air is an absorber of solar radiation—its quantity, not its quality, determining the amount of the absorption. Be that as it may, I have reduced the differences of maxima (which Hill calls the "excess temperature of the solar thermometer") to a common standard of cloud, relative humidity, and dew-point by means of the results obtained for Kenilworth in Tables III., V., VI. The steps of the process will be followed in the last three columns of Table VIII. Considering the outstanding amount of uncertainty in the different elements the agreement of one station with another shown by the last column is remarkable. Chakrata is the only station differing materially from the others, and this arises probably because faulty observing has given too great a temperature excess to start with. Adelaide, as it happens, is in nearly the same latitude as Leh; Kimberley is some 7° nearer the equator, and so should be expected to show a somewhat greater difference of maxima between sun and shade than either of these two.

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* S. A. Hill, *Indian Met. Memoirs*, vol. i., p. 377.

I have chosen Himalayan stations for this comparison because they stand at different altitudes near the same latitude. The outcome goes, I think, to show that the observations made in various places may be much more readily comparable than has sometimes been supposed. Given a uniform system of observing, under definite conditions of exposure, then it seems a fair inference that valuable and comparable data can be obtained. It is to be hoped, at any rate, that the hard names the black bulb thermometer *in vacuo* has been called will not deter observers from continuing to use it to the very best of their ability.

Some very elaborate theories have been constructed upon a basis of the absorption of heat by aqueous vapour. Tyndall and others have thought that the energy of terrestrial radiation is determined almost entirely by the quantity of transparent aqueous vapour in the air. "The presence of the vapour checks the loss, while its removal favours radiation and promotes the nocturnal chill." Tyndall also was of opinion that the same radiation was largely responsible for the heavy rainfall of tropical regions, and he added: "The aqueous vapour which absorbs heat thus greedily, radiates it copiously; and this fact must come powerfully into play in the tropics. We know that the sun raises from the equatorial ocean enormous quantities of vapour, and that immediately under him, in the region of calms, the rain, due to the condensation of the vapour, descends in deluges. Hitherto this has been ascribed to the chilling that accompanies the expansion of the ascending air; and no doubt this, as a true cause, must produce its proportionate effect. But the radiation from the vapour itself must also be influential. When a column of saturated air ascends from the equatorial ocean, the radiation from it is for some time intercepted, and in great part returned to it, by the surrounding vapour. But the quantity of vapour in the atmosphere diminishes rapidly as we ascend; the decrement of vapour tension, as proved by Hooker, Strachey, and Welsh, is much more speedy than that of the air itself; and, finally, our vaporous column finds itself elevated beyond the protecting screen which, during the first portion of its ascent, was spread above it. It is now in the presence of pure space, and into space it pours its heat without stoppage or requital. To the loss of heat thus endured, the condensation of the vapour, and its torrential descent, must certainly be in part ascribed." *

An explanation running upon similar lines was the carbonic acid theory of S. Arrhenius, invoked primarily to explain the Great Ice Age. On account of its historical importance, I venture to quote a passage from a most enthusiastic account of it by Dr. Nils Ekholm:—

"Among all the numerous hypotheses imagined in order to explain the great climatic changes of the geological ages, that worked out by S. Arrhenius on the ground gradually laid by Fourier, Pouillet, Tyndall, Langley, Knut Ångström, Paschen, and others, is the only one which has stood the test of a scientific examination. It is founded on the fact that carbonic acid, though as transparent as pure air to the solar rays, is partly opaque to the heat radiating from

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* J. Tyndall, "Heat a Mode of Motion," 1880, p. 383. Also by the same author, "On the Relation of Radiant Heat to Aqueous Vapour," *Phil. Trans.*, 1863.

the ground and the lower and warmer strata of the atmosphere. Owing to this the carbonic acid of the atmosphere acts as the glass of a greenhouse, letting through the solar rays, but partly retaining the dark rays emitted from the ground. Thus if the quantity of carbonic acid in the atmosphere increases, the temperature of the ground and the lower atmospheric strata will be raised, till the increase of radiation into space caused by the increase of temperature has restored the equilibrium between gain and loss of heat. But to this is added a circumstance which considerably adds to the influence of the carbonic acid. Aqueous vapour possesses the same remarkable property as carbonic acid, and is nearly transparent to solar heat, and nearly opaque to terrestrial heat. Aqueous vapour alone is, however, unable to produce any radical change of climate. For the quantity of aqueous vapour in the atmosphere is itself depending upon the temperature of the air; if this be lowered by some cause, for instance by radiation, the aqueous vapour is partly condensed and separated from the atmosphere, whereby its protecting influence is diminished, and then the increased radiation causes a new condensation of vapour, and so on. It is, therefore, only in regions and seasons already favoured by nature with a warm and damp climate that aqueous vapour alone is able to play the part of greenhouse glass; whereas in cold and dry regions, where the protection is most needed, aqueous vapour fails." *

These two descriptions are fairly typical, but differ in the important particular that whereas Tyndall's remarks are based upon some very high-class experimental facts, Ekholm's are based upon sheer assumption.† But in either case it is difficult to see where the great protection comes in; for at the best, especially on a rotating globe, the good absorber, and therefore good radiator, can only delay somewhat, and chiefly by absorbing its own radiation,‡ the final emission of heat into space. For it is to be noted

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* N. Ekholm, "On the Variations of the Climate of the Geological and Historical Past, and their Causes," *Q. J. R. Met. S.*, January, 1901. Some authors suggest that carbonic acid is an important constituent of the atmosphere of the planet Mars.

† See *inter alia* a notice by Cleveland Abbe and F. W. Very, of a paper by K. Angström, in *M. W. R.*, 1901, p. 268; J. Hann, "Handbook of Climatology," 1903, p. 399. There is an interesting "Report on Carbonic Acid," by W. C. Day, in Langley's "Researches on Solar Heat," p. 202. Incidentally the author mentions the theory of M. H. Schloesing that the ocean acts as a reservoir and regulator of atmospheric carbonic acid, confining its variations between very narrow limits.

‡ According to C. C. Hutchins and J. C. Pearson, a column of ordinary damp air, with a relative humidity of 78 per cent., 245 cm. thick, absorbs 60 per cent. of its own radiation, the other 40 per cent. being freely transmitted. "Air Radiation," *M. W. R.*, July, 1904, p. 314.

that radiation, like absorption and unlike reflection, is not a surface phenomenon, but takes place from the whole body of matter in question. In fact it is known that a stratum of any substance, however slight its emissivity for particular radiations, will, if only thick enough, behave exactly like a black body.*

It is to be noted that the suggestion that terrestrial radiation depends more upon the relative than upon the absolute humidity does not depend solely upon the observations of temperature cited at the commencement of this paper. Some years ago I published some results showing that under absolutely clear skies the air itself seemed to cool more rapidly when the relative humidity was low than when the dew-point was low.† Indeed no variation arising out of the absolute humidity could be detected with certainty. If, then, we can accept it as proved that the solar radiation is absorbed in proportion to the absolute humidity alone, while terrestrial radiation is absorbed in proportion to the relative humidity alone, the protective value of the atmosphere appears in a much more effective aspect. To start with, we shall have terrestrial radiation (say, *e.g.*, nocturnal cooling) proceeding more and more slowly as the temperature falls, even though the dew-point fall as dew is condensed out of the lower air. At high temperatures, under full sunshine, the emission to space may, in some cases, be almost as rapid as the reception of heat from the sun. At lower temperatures, even with the same quantity of moisture, the emission may be extremely slow. An elevated sheet of air containing a given quantity of aqueous vapour at a given temperature may, on account of a low absolute humidity, permit the solar radiation to pass with comparative freedom, while on account of a high relative humidity the return terrestrial radiation might be effectually checked. In this case the sheet of air does bear some analogy to the glass of a greenhouse so dear to the heart of the orthodox meteorologist. Should the temperature of the elevated sheet of air, however, happen to be high, so that its relative humidity is low, then the analogy breaks down, for the terrestrial radiation is no longer checked by it. By way of restoring the analogy, does a hot sheet of glass absorb as much dark heat as a cold sheet?

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* See P. G. Tait, "Heat," 1895, p. 262; J. Tyndall, "Heat a Mode of Motion," 1880, p. 312. The former gives a mathematical demonstration.

J. R. Sutton, "Aqueous Vapour and Temperature," *Symons's Met. Mag.*, 1895, vol. 30, p. 104. The matter is being re-examined.

RESULTS OF FURTHER EXPERIMENTS ON TABLE MOUNTAIN FOR ASCERTAINING THE AMOUNT OF MOISTURE DEPOSITED FROM THE SOUTH-EAST CLOUDS.

By R. Marloth, Ph.D., M.A.

(Read March 29, 1905.

(Plate I.)

It will be remembered that about two years* ago I laid before the Society the results of some observations on the amount of moisture deposited from the south-east clouds on Table Mountain, and that in summing up these results I stated "that the object of my work had been to ascertain more exactly the climatic conditions under which the plants on the mountain existed. That side of the question has been answered. Their summer is not dry. Their climate is that of a swamp—a permanent swamp in winter, a periodical swamp in summer, which dries up during a long spell of fine weather, but becomes soaking wet during the days of the south-east cloud. These results explain why such luxuriant and thickly-set vegetation prevails on the upper parts of our mountains . . . and why there are little lakes, even late in summer, on the top of Table Mountain, as well as close to the summit of Dutoit's Peak. . . . The purely meteorological side of the question I leave to others for further investigation."

The method employed consisted in keeping two 5-inch rain-gauges on the top of the mountain—one of the ordinary kind, and the other one surmounted by a framework which carried an imitation bunch of reeds 1 foot high. The quantities which I had obtained in my measurements were, however, so large that they met with a considerable amount of doubt, although I had taken special care to point out that I did not look upon them as representing a corresponding rainfall.

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* R. Marloth, "Results of Experiments on Table Mountain for Ascertaining the Amount of Moisture Deposited from the South-east Clouds" (Trans. S.A. Phil. Soc., vol. xlv., p. 403, 1903).

The main objection raised against the method of measurement employed was that an isolated group of reeds might capture such a quantity of moisture, but that others standing behind the first one or the first row would not be able to do so, owing to the front row acting as a screen and straining the moisture out of the passing cloud—that, in fact, there would not have been sufficient moisture left to supply the reeds in the rear.

The Society having decided that further experiments were desirable, the Council requested me to undertake them, voting at the same time the necessary funds for the acquisition of additional gauges. With the help of some friends and the assistance of the city water-engineer, Mr. Wynne-Roberts, and a member of his staff, I was enabled to continue the observations for two years; hence I think that it may interest some members of the Society to hear what has been the result of this work.

Before stating these results I should like to refer briefly to the main objection mentioned above, and to see what an amount of moisture would be available in a south-east cloud. In order to simplify the calculations, I beg leave to employ metric measures, and I shall put the height of the mountain, roughly, at 1,000 m., the exact figure being 1,082 m. The lower limit of the cloud varies, of course, considerably; but it may be put at an average of 600 m. above sea-level, which means that each layer of the cloud, from the time it is formed until it reaches the summit, has to ascend 400 m.

As the air at the lower limit of the cloud is saturated with water vapour, apart from the water in liquid form which is suspended in the air and forms the cloud itself, and as such air with an initial temperature of, say, 20° C. reduces its temperature by 0·44° C. for every 100 m., the total decrease of temperature during the rising from the 600- to the 1,000-m. level would be 1·72° C.*

If the temperature of fully saturated air of 20° C. be reduced by one degree, a condensation of 0·98 grammes of water will take place in every cubic metre of such air; hence in our case 1·68 grammes of additional water—above that which originally formed the cloud—would be floating in every cubic metre of air on its arrival at the eastern edge of the top of the mountain.

The velocity of the south-east wind has been found occasionally to exceed 40 miles an hour; but let us take a velocity of 20 miles only, which corresponds, roughly speaking, to 8 m. per sec. As there are 3,600 seconds in an hour, a velocity of 8 m. per sec. means that during one hour 28,800 cub. m. of air would pass successively over the same surface of 1 square m.; and as each cubic metre of air is carrying 1·68 grammes of suspended water, the total quantity of it passing this area would be 48,384 grammes, a quantity which, if deposited on an horizontal surface of 1 square m., would be equal to 48 mm. of rain, or, in round figures, 2 inches per hour.

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* These calculations are based upon Hann's "Lehrbuch der Meteorologie," pp. 240, 241.

That is taking into consideration only a layer of air 1 m. thick; but the cloud is often 100 or more metres thick, and as the masses of cloud in their course over the mountain are hurled and whirled about, any portion of the lower layer, that may have been deprived of its suspended moisture by the reeds, is constantly mixed with fresh masses from above, and there is evidently much more moisture available than many miles of reeds * could ever capture.

It is this large excess of condensed moisture which floats about in the cloud in the form of small drops that accounts for the surprisingly large deposit of water on the reeds and rocks and all other obstacles in their way. Not all clouds possess such a soaking effect. I have sometimes spent many hours on the mountain in thick clouds without finding any moisture on the bushes or any water in my gauges. That is specially the case during northerly winds; but when a real south-easter blows things are quite different, and I am sure it would simplify the discussion considerably, if some of the sceptics would give me the pleasure of their company on such an occasion.

Such a cloud is really an intimate mixture of an ordinary cloud with a very finely distributed rain in its initial stages, and as this mass is moving with great velocity, the minute raindrops are not allowed to fall, and are captured only when they come into contact with a solid body.

Another objection against the method employed, and the conclusions drawn from the observations, has been laid before this Society by Mr. Charles Stewart,† in a paper read in July, 1903, and entitled "A Note on the Quantities given in Dr. Marloth's Paper on the Moisture Deposited from the South-east Clouds." Mr. Stewart took considerable pains to calculate the total surface of the vertical superstructure employed by me, and found that the vertical "catchment area" of the gauge, *i.e.*, the surface of the framework, reeds, and other parts amounted to 114 square inches, which is six times as much as the horizontal area of the gauge. I am much obliged to Mr. Stewart for this calculation, for it enables those who are not familiar with the internal condition and state of a south-east cloud to recognise at a glance what an enormous surface a bunch of reeds only one foot high exposes to the passing cloud. When, however, Mr. Stewart goes a step further, and divides the total quantity of moisture collected in the gauge by the number of vertical square inches found by him, and gives the factor obtained in this way as the true deposit of moisture per square inch of the gauge, I fail to comprehend his reasoning.

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* I repeat the explanation on p. 404 of my previous paper, that these plants are not real reeds, but resemble them only, belonging to the order *Restionaceæ*.

† Charles M. Stewart, B.Sc., Trans. S.A. Phil. Soc., vol. xlv., p. 413, 1903.

My 5-inch gauge carried twenty-four vertical wires and reeds, corresponding to 176 reeds per square foot of ground. If we find that a layer of water 1 inch thick has been deposited on a piece of ground 1 square foot in extent, we must conclude that the plants growing on that patch have this quantity of water at their disposal, the usual losses, of course, being left out of account. What could it matter, as far as the recording of a quantity of water per square inch is concerned, whether this water was collected directly from rain by the horizontal surface of the ground or indirectly from the clouds by means of the 176 vertical reeds standing on this area?

There are several other misunderstandings in Mr. Stewart's paper which would require adjustment, but I fear that this would take up too much of the time of the Society. I must, however, refer to a source of error which has not been mentioned as yet.

During my earlier experiments I had assumed that the difference between the records of the two gauges, viz., the ordinary rain-gauge and the reed-gauge, represented only moisture captured by the reeds, exclusive of all rain. From the daily readings of the gauges at the Woodhead reservoir it is, however, apparent, that during rain the gauge with the reeds collects much more water than the open one. There is no uniform ratio between the two, the gauge with the reeds showing during ordinary rain from three to four times as much as the other one; but during "misty" rain, when the open gauge records sometimes only $\frac{1}{100}$ or $\frac{1}{10}$ of an inch, the capture of the reeds was ten or even twelve times as much.

This variation of the ratio shows how effective the vegetation is in comparison with the bare ground or rocks in capturing moisture apart from the real rain, but it will be impossible to ascertain exactly how much be due to the one source and how much to the other. As these experiments were never intended to give accurate quantitative returns which could be entered alongside the rainfall records, but merely to demonstrate that much more water was deposited on the mountains than the ordinary rain-gauges indicated, especially in summer, it will not matter if we exclude all the periods during which any rain was recorded, and utilise for our purposes only those records which are not affected by this error.

The following Table gives a summary of the results for periods during which no rain was observed:—

Woodhead Reservoir. Alt. 2,496 feet.			Maclear's Beacon. Alt. 3,500 feet.		
	Inches.	Number of days.	Inches.	Number of days.	
December, 1903.	1·35	8	—	—	Gauge standing in the open
January, 1904...	1·58	5	9·55	7	
February, 1904.	2·18	6	4·56	9	
March, 1904.....	3·72	7	5·0	5	
January, 1905...	3·14	12	—	—	
February, 1905.	2·31	9	—	—	

One of the special questions I wanted to decide in my recent experiments was to ascertain, to what extent reeds and bushes were sheltered by others standing in front of them. For this purpose I had placed one gauge in the open as before, one in the midst of a thicket of bushes 5 feet high, and one in the centre of a field of high reeds, the upper surface of which was level with the top of the frame of the gauge. The gauges near Maclear's Beacon were read weekly, and another one at a lower elevation, viz., in front of the caretaker's house at the Woodhead reservoir, daily, by Mr. Thorsen, who took great interest in the work. The following table gives his observations for one month of each year, the other months being practically of the same nature.

We found that there was a considerable screening effect exercised by the outer rows of bushes and reeds, especially during short periods of clouds, but that the quantity which did reach the sheltered gauges during longer periods of south-east clouds was far in excess of the total of the rainfall for the summer months. On an average the gauge in the interior of the thicket of bushes captured about one-third of that in the open, while the gauge which was practically hidden in the reeds collected from one-fourth to one-eighth of the amount recorded by the gauge in the open.

In connection therewith I may state, that I have checked these figures on several occasions by ascertaining the yield of the gauges during periods of one or two hours only. Sometimes even the gauge in the open captured practically nothing from the passing mist, while on other days one could watch the water dropping in.

WATER COLLECTED BY THE ORDINARY RAIN-GAUGES AND GAUGES WITH REEDS ON TABLE MOUNTAIN.

	Near Maclear's Beacon. Alt. 3,500. January, 1904.		Woodhead Reservoir. Alt. 2,496. January, 1904.			Woodhead Reservoir. Alt. 2,496. January, 1905.		
Date.	Rainfall.	Gauge with Reeds.	Rainfall.	Gauge with Reeds.	Wind and Weather.	Rainfall.	Gauge with Reeds.	Wind and Weather.
1					W., fine		**1·12**	Strong S.E., misty
2	0·61	4·75	0·53	2·37	Rain during night			Fine, S.E.
3					N.W., cloudy			Fine, N.W.
4			0·04	0·12	S.E., misty		**0·13**	Light S.E., mist during night
5				**0·02**	S.E., slight mist			Light S.E.
6	0·04	4·40			S.E., strong		**0.24**	N.W., misty, cloudy [night
7					S.E., strong	0·45	6·15	N.W., misty, rain during
8					S.E., strong	0·10	0·82	N.W., misty, light showers
9			0·70	1·80	N.W., rain during night	0·44	1·80	N.,misty,cloudy,light showers
10			0·27	3·05	N.W., rain during night	0·21	0·83	N., misty, light showers
11			0·11	1·25	N.W., rain during night			N., light, fine [ing night
12	0·65	20·62	0·07	0·22	Misty, cloudy		**0·31**	N., light, misty, and S.E. dur-
13					S.E., misty		**0·10**	S.E., misty, cloudy
14				**0·12**	S.E., misty		**0·57**	S.E., misty, cloudy
15			0·01	1·02	S.E., misty and cloudy			S.E., fine
16				**0·02**	S.E., strong			S.E., fine
17	0·03	8·10			S.E., light			S.E., fine
18					N., light			W., light, fine
19				**0·97**	S.E., misty		**0·02**	N.W., moderate
20			0·01	2·17	S.E., misty and cloudy			S.E., fine
21				**0·45**	S.E., misty and cloudy			S.E., fine
22					Fine		**0·15**	S.E., fine, misty during night
23					N.W., fine		**0·25**	S.E., misty during night
24		**9·55**			S.W., fine	0·03	**0·40**	S.E., misty, cloudy, slight rain
25					S.W., fine [night			S.E., cloudy
26			0·09	0·15	N.W., light rain during	0·01	1·41	S.E., misty, cloudy
27					N.W., cloudy		**0·15**	S.E., slight mist
28	0·11	0·85			N., light and cloudy		**0·03**	S.E., fine [night
29					S.E.	0·21	1·36	S.E., misty, slight rain during
30					S.E.		**0·02**	S.E., fine
31		**0·15**			S.E.			S.E., fine
Tls.	1·44	48·42	1·83	13·73		1·45	15·86	

It had been my intention to include all these figures in this paper, when a period of south-east clouds of unusual duration and vehemence rendered this quite unnecessary. You will no doubt remember that at the end of February and the beginning of this month a violent South-east storm raged throughout South Africa for nearly a week. There were abundant rains in all the eastern, southern, and central parts of the Colony, as is usual during such a severe S.E. wind, but no rain of any significance fell during that time on the Peninsula or in its neighbourhood. The gauges had been read on Saturday, the 25th of February, and, noticing some signs of a change of weather on Friday, the 3rd of March, I went up that afternoon to read them again, although the storm was still raging with unabated vigour.

I am almost afraid of stating what I found in the gauge standing in the open, for it was equal to 21·2 inches of rainfall. We may,

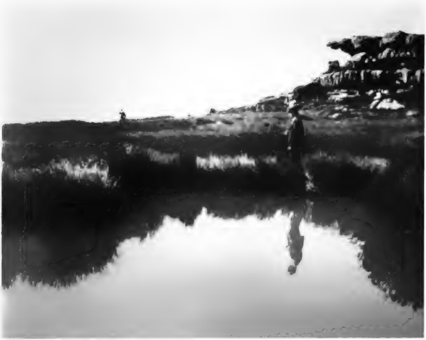


Photo by R. Marloth. West, Newman proc.

THE LAKE ON THE TOP OF TABLE MOUNTAIN WHICH OWES ITS PERMANENCE TO THE S.E. CLOUDS.

however, leave this figure out of account altogether, for the gauge which was practically hidden in the reeds, just as if it were standing in the midst of a luxuriant cornfield, showed 6·1 inches of moisture, and that for a period of six days, during which the ordinary rain-gauge at Maclear's Beacon recorded 0·15 inches of rain. I think it will be admitted that there are no other figures wanted. As a matter of fact, for any one who visited the mountain on that day or soon afterwards no figures were necessary at all to convince him of the enormous quantity of water which this south-easter had left on the mountain.

The upper plateau was practically a swamp from one end to the other; everywhere one met with pools of water; the little lake on the top had double the size and depth it usually possesses at the end of the summer, and the few late blooms of the gorgeous *Disa uniflora*, which I found in the fir-tree valley, were partly submerged on the borders of the swollen stream. And there had been no rain worth mentioning for 23 days.

As stated in my previous paper, I do not look upon these figures as being equivalent to records of rainfall as far as the general water supply of the streams is concerned, for during rain a great deal of water runs off from the bare rocks and reaches the streams immediately, while this moisture is captured only where sufficient vegetation exists, which, on the other hand, retains a large proportion of it in the spongy root work. Yet observations and gaugings made at some of our larger mountain streams have shown, that a considerable rise of the rivers may be effected by a long-continued south-east wind, although no rain had fallen in the catchment area.

There can be no question that the vegetation of our mountains is a very important factor in the regulation of the water supply of the springs and streams, and that this influence is exerted in two ways. Firstly, by capturing a not inconsiderable amount of moisture from the south-east clouds, which would escape if the mountains were formed by bare rocks only; and, secondly, by protecting the water which has accumulated in the soil and the rocks against the sun and consequent rapid evaporation. With regard to the loss due to evaporation I may be allowed to mention the experience of the Cape Orchard Company at Hex River.

Mr. Dicey has kindly informed me, that the mountain stream, which the Company uses for driving their Pelton wheel, gives them in summer 60 horse-power, but that on bright days the quantity of water in the stream generally decreases so much that about 2 p.m. they cannot obtain more than 55 or 54 horse-power. Towards evening it rises again and regains its full force by 11 p.m.

A much more drastic illustration of the protective influence of the vegetation was given, however, last year, when on the 13th and 14th of December a mountain fire destroyed the grass and bushes in the kloof from which their supply is drawn, and when three days later the stream had dwindled down to such an extent, that it could not produce more than 20 horse-power.

Even if one should not sufficiently realise the moisture-catching effect of the vegetation, its protective function and preserving influence on the water supply of the mountains cannot be over-estimated, and I trust that the authorities as well as private owners may recognise, more readily than is being done at present, the importance of preserving and even nursing the plant covering of our mountains.

RECORD OF SOUTH-EAST CLOUDS ON THE ZWARTEBERGEN, AS SEEN FROM THE VILLAGE OF PRINCE ALBERT.

By JOHN H. WHAITS.

1903.		1903.		1904.	
October 1	Morning	December 1	Evening	January 30	All day
2	Afternoon	3		31	,,
3	All day	5 days absent			
4	Morning	11	Evening	February 1	,,
5	,,	17	,,	7	,,
11	Evening	5 days absent		8 days absent	
13	,,	24	Evening	16	All day
14	Morning	25	,,	17	,,
17	,,	6 days absent		18	,,
20	All day			20	Evening
3 days absent				21	Morning
24	Morning			22	All day
28	Evening	1904.		23	,,
5 days absent				24	,,
				25	,,
November 7	Aft. & evn.	January 1	Evening	26	,,
8	Morning	2	,,	27	,,
11	Evening	3	All day	28	,,
12	All day	4	Evening	29	,,
13	,,	5	,,		
14	,,	6	,,		
15	Morning	7	,,	March 1	All day
16	All day	12	Aft. & evn.	2	,,
19	Aft. & evn.	6 days absent		3	,,
21	Evening	21	Evening	4	,,
22	All day	22	,,	7	,,
23	Aft. & evn.	25	,,	8	,,
24	,,	26	,,	12	,,
25	All day	27	,,	13	,,
30	Aft. & evn.	28	,,	15	,,

In order to show over what a large portion of South Africa the influence of the south-east clouds asserts itself, I give a list of observations on their occurrence on the Zwartebergen, kindly made at my request by the Rev. J. Whaits at Prince Albert during the summer of 1904. This list will show how numerous the cloudy days are on those mountains, and of what importance these clouds must be to the water supply of the streams rising in these and other ranges of South-Western Africa.

It is interesting to see that a view quite similar to that which I hold concerning the important function of the vegetation on our mountains in connection with the water supply of the springs has been expressed by such an eminent authority as Professor Cleveland Abbe, of the Weather Bureau of the United States Department of Agriculture, with regard to the Island of Ascension. The principal water supply of the Naval Station on the island comes from the summit of Green Mountain, which is several miles away. The upper portion of the mountain is covered with vegetation, and nearly all the water on the summit comes from slight showers and the steady dripping from trees which are enveloped in the clouds. These trees simply mechanically collect the water-drops which are produced from the condensation of the water vapour in the ascending cooling air.

In conclusion, I wish to point out once more, that I do not consider the measurements given in these communications to represent real rainfall. In my previous paper a quantity of 75 inches was mentioned for a certain period, and the Table on page 102 of this paper shows a record of 48 inches for one month. Even if we discard 90 per cent. of these quantities, the remaining one-tenth is still so largely in excess of the rainfall recorded in the ordinary gauge, that I think even the most sceptical critic will recognise, that this quantity of water, gathered during the dry season of the year, must exercise a considerable influence on the vegetation of the mountains, as well as on the springs.

ON THE DISCOVERY OF A LARGE NUMBER OF IMPLEMENTS OF PALÆOLITHIC TYPE AT VEREENIGING, TRANSVAAL.

By J. P. Johnson.

(Read March 29, 1905.)

(Plate II.)

The important discovery of stone implements which forms the subject of this paper was made towards the middle of last year by my friend, Mr. T. N. Leslie, of Vereeniging, who is already well known to the members of this Society on account of his contributions to our knowledge of the fossil flora of South Africa, and who has very kindly placed his material at my disposal for description.

The implements, of which there are over fifty finished examples, are of Palæolithic types and, being associated, constitute a valuable addition to our data respecting the development of that stage of culture in South Africa.

Shortly after the find I went over the site with Mr. Leslie and was myself fortunate enough to obtain several specimens, including two exceptionally fine ones. Since then I have paid two or three further visits to the neighbourhood.

The Vaal in that part has cut a channel deep into the solid rock, and on top of the cliff thus formed and extending, to my knowledge, some distance east and west of the town, is an old river terrace consisting of gravel and small boulders embedded in and overlaid by loam. There is a small pit in it, east of the town, where flakes occur in great profusion, and nearly every pebble (which are all of quartzite) has been chipped. They appear to be largely the result of unsuccessful attempts at manufacturing implements. No finished implements have been found in this pit.

Mr. Leslie's find is some distance west of the town, where long stretches of the terrace have been furrowed and spread out by the rain. There, for many hundreds of feet, unfinished implements occur in the greatest abundance, the flakes produced in their manufacture by the thousand, while here and there completed specimens were met with. The quartzite seems to have been of too coarse a grain, as a rule, for suitable working, as nearly all the failures and very few finished implements are in this material, the majority of the good specimens being of greenstone. One or two unfinished examples of chert were also found.

It is quite clear that these implements must have been made very close to where they are now found. Very probably the gravel is the sweepings of an adjacent land surface where the implements were manufactured on a large scale. Many of them are as sharp and fresh as on the day they were made, while obliteration of the sharpness of the facets in others is more often due to weathering than wear.

Although the Palæolithic facies of these implements is unmistakable, a difference in detail is noticeable when they are compared with the typical forms.

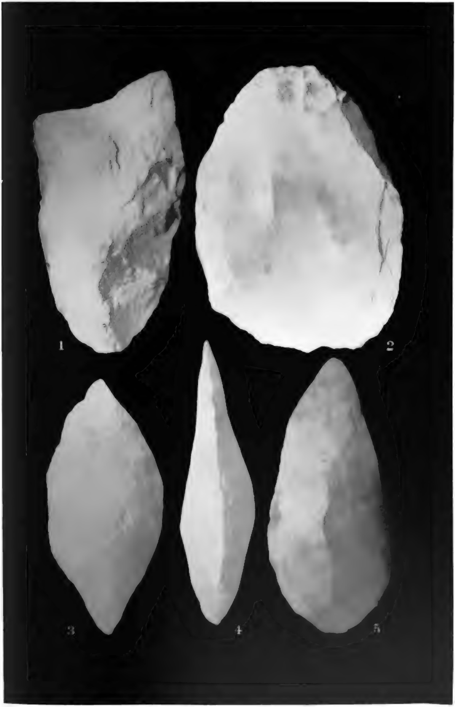
The distinctive implements found in the valley-drifts of the Thames Basin in Britain, which may be taken as typical of the Palæolithic stage of culture, are divisible into two groups—namely, tongue-shaped and discoidal.

The tongue-shaped implements, which constitute the majority, are, as their name implies, shaped like a tongue, being as variable in form as that organ. They are chipped completely out of stone (flint), the chipping being done in such a way as to leave a sharp edge along the greater part of the periphery. They are sometimes chipped into delicate, tapering points, and sometimes into thin flat blades, but more generally into a form midway between the two. The edge seldom passes round the thick end, or butt, of the implement.

The discoidal implements have an oval periphery with the edge continued all the way round.

Examples of both extremes of the typical tongue-shaped implements are to be noted among the Vereeniging specimens. The great majority, however, are of the same general shape as the average tongue-shaped implement, but differ in that the edge is continued right round the butt. They are thus intermediate between the typical tongue-shaped and discoidal implements, some approaching the last mentioned very closely, though none quite. They might be correctly described as almond-shaped.

Associated with these are a number of implements which, though possessing the characteristic Palæolithic style and quality of work-



West, Newman, proc.

JOHNSON: IMPLEMENTS OF PALÆOLITHIC TYPE.

manship, are of quite a different type to any that have been found in the Thames Basin. They bear some resemblance in their shape to the well-known Neolithic axe-heads, but the chisel-like edge has been produced by the removal of two large flakes instead of by grinding. I am inclined to think that they are forerunners of the Neolithic axe-heads, and that they were employed for the same purposes. Fig. I. illustrates a specimen in Mr. Leslie's collection. It is, perhaps, not a very favourable example to bring forward in support of my view, on account of the peculiar inclination of the chisel-edge to the longitudinal axis. This feature, however, is often met with in the Neolithic axe-heads, it being even more marked, for instance, in some specimens in my collection from the Gold Coast. In most of the Vereeniging implements, however, the chisel-edge is in its normal position, namely, at right angles to the long axis. An example found by myself is so neatly and symmetrically shaped that but for the evidence of the others it would certainly have been taken for a Neolithic axe-head, the fact that the chisel-edge was obtained by chipping instead of by grinding being obscured by the slight amount of weathering it had undergone.

Mr. Leslie's specimens also include one or two examples of the well-known group, consisting of a big flake worked on one side only. These particular examples have the appearance of large massive scrapers, but it is more probable that they were used as choppers.

Three implements of special interest are shown in Figs. II., III., and IV. That represented by Fig. II. is a rough implement of irregular outline and primitive form. It would pass as an example of man's first attempt to manufacture an implement of that class.

The two implements represented by Figs. III. and IV. are unique. The former side and edge views of a long knife-like variety of the tongue-shaped type, noteworthy for its fine workmanship. The latter represents an implement which is peculiar in being pointed at both ends. Both are forerunners of the well-known Neolithic forms.

SOME NOTES REGARDING SOUTH AFRICAN PHARMACOLOGY.

By C. F. Jubitz, M.A.

(Read April 26, 1905.)

We live in a country of magnificent possibilities—agricultural, industrial, educational, commercial; the inhabitant of this land who journeys through life with open eyes is bound to become cognisant of such, and of many besides, no matter whether he be engaged in the study of literature, the pursuit of art, or the application of science. Possibilities many—potential sources of wealth or of utility—but unworked mines,—unworked, because in some cases we do not know how to work them, in others because we are sceptical regarding the advantages they are likely to yield; into some we are not bold enough to venture for fear of the risks and perils we may encounter; others again there are where operations, once begun, are at a standstill because the means are exhausted, the energies have flagged, or the labour spectre bars the way—we simply have not the men to work them. It is to a mine of the last-mentioned class that I propose to direct attention.

"There can be no doubt amongst reasonable men that, judging from the vast extent of the South African territory, and from the richness of its almost inexhaustible Flora, many highly useful drugs will still be discovered. However, the greater part of our information on this point we owe, not so much to scientific research as to the experience of the colonial farmer residing in the more remote parts of the interior, to occasional travellers or to the wandering native."

Nearly half a century ago Pappe wrote these words. They are absolutely true to-day: the many drugs still await discovery, scientific research there has been next to none, while those who, like Andrew Smith, have during the interim compiled manuals of South African Materia Medica, have derived their information not from the scientist, but have perforce found themselves relegated to the farmer, the traveller, and the native. There has been scarcely any progress during these fifty years.

In a restricted sense the word pharmacology is often used as denoting scientific investigation with regard to the remedies mentioned in the pharmacopœias, and especially in connection with the needs of medical practice. The term has, however, a much wider meaning, under which the scope of the investigation is enlarged so as to comprise all chemical principles capable of acting beneficially or otherwise upon the human system. During the course of such investigations questions are frequently presented for settlement which, though not falling directly within the sphere of medical practice, are yet of great value in leading us to understand the nature of certain materials which the physician either already employs in his practice or would so employ if the potentialities of such an agent were more clearly grasped.

"Fire and water"—so runs the old proverb—"are good servants, but bad masters." One scarcely needs to be a physician or a chemist in order to realise that a very similar aphorism may be applied to many of the remedial agents employed in medical practice at the present day. An ounce may cause speedy death, but a few grains may save life, or, to come within still narrower limits, we know that of the powerful alkaloids a single grain would bring about a fatal result, whereas the twentieth part of a grain may restore circulation where the heart has all but ceased to beat. We may even proceed further, and, under special conditions, avert a fatal issue by using that which, in ordinary circumstances, would act as a poison. To exemplify: Atropine, as we know, produces an effect which shows itself in the dilation of the pupil of the eye: physostigmine has the opposite effect—it causes the pupil to contract. Each of these would, in this respect, act as the antidote of the other, and so restore equilibrium. But equilibrium may be disturbed by other means than the ingestion of a poison, and if the physician is aware of some principle, ordinarily considered poisonous, but whose poisonous action tends in a direction diametrically opposite to that of the disturbing cause, then judicious administration of what would otherwise be a poison may restore health. Take a simple case in illustration: Digitalin increases the force of the heart's contraction, and contracts the muscles so powerfully, when taken in large doses, that the heart may remain contracted, causing death. Now when, in certain forms of heart disease, that organ becomes enfeebled, and fails to contract regularly with sufficient power to project the blood through the arteries, the administration of small doses of digitalin, by causing a more powerful contraction of the muscles of the heart, may restore a failing circulation.

It is obvious that if we know wherein the action of a poison consists, we may, by judiciously employing that poison at the right juncture, counteract opposing forces which are threatening to destroy life. We may, however, have the remedy for the disease at our very door, and, through want of knowledge, fail to apply it. Hence the need of the scientific research to which Dr. Pappe alluded fifty years ago. We can scarcely take up a periodical bearing on medical science without coming across records of investigations in regard to new drugs; some of these investigations are physiological, searching out information respecting the action of the drug on living animals or human beings; others are chemical, and aim at discovering the inherent nature of the active principle itself and its relation to other known substances. That there is an immense field for research in connection with the poisonous, and possibly medicinal plants indigenous to this sub-continent must be patent to every one who has even touched the fringe of the subject; but while there is this wealth of information ready to be worked, it lies latent for want of workers.

An entire century has passed since its present possessors entered upon occupation of this land, and, to our discredit be it said, the aboriginal native to-day still knows more about the value of some of our indigenous medicinal plants than we do, and all the appreciation that we show is to clap him into prison if, in his excess of zeal, untempered by the culture which we possess but decline to use, he gives his patient too large a dose, and so kills where he intended to cure. In other colonies it has not been the habit to pause so that the sons of Ham may lead the way of knowledge. Had the Spaniards acted upon this principle, that valuable drug quinine would have been unknown as one of our most important febrifuges. There is no evidence that the Indians knew the value of Peruvian bark before the Spaniards colonised their country. It was left for the colonists to exploit it. With us the native scientist—pardon the term!—has led the van, and, notwithstanding the wilderness cry of Pappe, and its later echo by Andrew Smith, we have not yet considered the trail worth following up. For over fifteen years there has been a Government Analytical Laboratory in existence, but even that institution has not had the opportunity of advancing the subject much further, for the investigations of the Government analysts have been limited to attempts to identify the drugs when the over-zealous Kaffir doctor has been indicted for culpable homicide. It is not from that point that the matter should be approached; it is not consonant with the dignity of a scientific investigation of so important a nature that it should be grudged the expenditure of any time and labour other than that casually bestowed upon it as the mere side-issue in the criminal prosecution of a Kaffir or Hottentot. The plant drugs and poisons of a country so richly endowed with them are of quite sufficient importance *per se* to warrant their being made the subject of special research under the auspices of the State. As yet neither State nor University nor College has bestowed any attention whatever on this branch of science, nor have we amongst our local scientists men of pecuniary resource sufficient to enable them unendowed to undertake so laborious and costly a study, for hope of return there can be none. At the same time it must be admitted that a few diligent investigators have, with the limited means at their command, accumulated, as far as isolated individuals can under the circumstances, a fair store of valuable information. With special reference to the subject under consideration, these investigators may be told off upon the fingers of one hand: in fact, to take the matter of chemical research generally, although we pride ourselves upon our advanced civilisation, if we consider what has long been done, and is indeed at this very moment being accomplished in this direction in Japan—a country in the throes of a terrible war—by the Japanese, whom we have been too apt to regard as entirely beneath us in intellect and culture, we shall be bound to admit—did we but realise the facts sufficiently—that as regards chemical research South Africa occupies a very backward position amongst the countries of the world.

Dr. Pappe's "List of South African Indigenous Plants used as Remedies by the Colonists of the Cape of Good Hope," published in 1847, was perhaps the first attempt to deal with the subject of pharmacology in this connection; and yet the pamphlet—for it comprised only fourteen pages at its first appearance—dealt with the matter almost wholly from the botanical standpoint, the medical aspect being quite subsidiary, while the chemical nature of the drugs enumerated is alluded to only in the most casual way, and even that but occasionally and in the vaguest of terms.

Some thirty years later Cape Aloes and Buchu were made the subjects of special monographs, and about the same time an account was published by Dr. Grey of a case of poisoning in the Middelburg Division by the agency of certain bulbs. None of these, however, do more than touch on the chemistry of the drugs they discuss, and, where they do otherwise, as frequently as not the writers fall into error. Thus Grey refers to the ornithogalum poison as if it were strychnine, or, at all events, a close connection of that alkaloid; whereas the active principle is, in all probability, a glucoside, seeing that it is destroyed by boiling.

Smith, in his "South African Materia Medica," approaches nearer to what may be called the pharmacology of our flora than any strictly botanical writer, and in this respect the enlarged third edition of that little work, published in 1895, is a distinct step in advance of any previous publication.

Not even Smith, however, although he dealt more extensively than any previous writer with the physiological effects of many native herbs, can be considered as contributing much to the knowledge we possess regarding the nature of the drugs themselves. He hazards, it is true, a few guesses, notably in the earlier editions, but without the authority of direct chemical confirmation, it is not unusual for such hypotheses to turn out as erroneous as Grey's identification of the ornithogalum poison with strychnine. A very similar mistake to this is the sweeping statement made in the earlier editions of Smith's "Materia Medica" to the effect that *Acocanthera venenata* contains the alkaloid brucine. This error has been rectified in the last edition.

As a matter of fact I know of only one published paper that can claim to be at all indicative of the course that experimenters in this direction should adopt, namely, Mr. Isaac Meiring's "Notes on Some Experiments with the Active Principle of *Mesembrianthemum tortuosum*, L.," read before a meeting of this Society in September, 1896, and published in Volume 9 of the Society's *Transactions*. Mr. Meiring was successful in isolating an alkaloid, which he tested by means of several well-recognised chemical reagents, and recorded the results, as well as the physiological experiments which he performed, in his paper.

I do not wish to assert that no other investigations of such a nature have ever been made, but, if they have been performed, they have certainly not been made public, if I except the few disconnected notes on the subject which have from time to time appeared in the annual reports of the laboratory under my charge.

It is far from my intention to claim that in that laboratory anything at all approaching to an adequate research into the nature of any new or unknown drug has been made. I have already stated the reason why this cannot be: unfortunately, such researches need more freedom from the special exigencies of the moment than it is usual to find in our Government laboratories. I only desire to say a few words about what has actually been done—although in each case the investigation, I dare not dignify it with the name of research, has been but the handmaid to the criminal procedure of the law courts—with the hope that my remarks may act as an incentive to provide for more systematic researches, and for enlarging their scope, so that they may include the study of the active principles of many indigenous plants, which are at present most imperfectly known, and in the trust that measures may be adopted for testing therapeutically the value of these active principles.

The nature of some of the difficulties attendant upon such cursory investigations as have been made may be gleaned from the following description of what usually occurs. For some ailment, real or imaginary, a person is treated by a native medicine-man, is possibly over-dosed and dies. The stomach, or its contents, is forwarded for analysis, not always accompanied by some portion of the plant held responsible for the fatality. Generally, however, it is accompanied by a fragment of some plant, it may be an inch or two of root or a few leaves. It is most unusual to receive any flowers or fruit, so that in many cases the plant can hardly, if at all, be identified. As often as not it is a matter of uncertainty whether the accompanying plant is really of the same species or order as that taken by the deceased, and there is no clue whatever on the subject. The first step in the actual investigation is usually that of ascertaining whether any alkaloid or glucoside is extractible from the plant, and if so whether it yields any characteristic tests whereby it may be identified on a future occasion. Often the small quantity of plant material received is far too minute to extract anything satisfactory from; in such cases request is made for a larger quantity, provided the plant can be identified. Sometimes this cannot be done, and so one channel of investigation is closed. On other occasions a larger supply is received in response to the request; one glance may then be sufficient to reveal the fact that it is obviously from a different plant; or it may be accompanied by a statement to the effect that it is wholly uncertain whether it is from the same plant as the original sample which, in turn, may not be identical with that taken by the deceased. Now and then it has happened that the links of the chain are complete, and the plant extract, upon application of certain tests, has responded in some characteristic measure; the next step is to identify the contents of the stomach, and this is done by application of the same tests to which the plant responded. Sometimes the results are negative, sometimes positive; but negative results do not imply that the plant decoction was not partaken of, nor do positive results prove that it caused death. Physiological experiments have now to be performed, and mice, rats, guinea-pigs, rabbits, and dogs are usually experimented upon. All these experiments have to be carried out and completed within a specified time, for the point to be decided is the purely legal one, whether the deceased died from the effects of a poison administered by the accused.

One of the first cases of poisoning with an indigenous plant to come under my notice officially was that of a Kaffir woman at Port St. John's, who died after partaking of a decoction said to have been made from *Trichilia Dregei*, E. Mayer, belonging to the *Meliaceæ*, an order comprising several plants which contain distinctly active principles. The bark was subjected to Dragendorff's method of treatment for the extraction and isolation of possible poisonous principles, but, with the exception of the acidulated aqueous solution obtained from the ethereal extract, which yielded thin, slender, needle-shaped crystals after the evaporation of the chloroform wherewith the above solution, previously rendered alkaline, had been shaken up, no solvent used extracted any active principle, nor did any of the residues yield any characteristic reactions with any of the alkaloidal reagents. The small needle-shaped crystals referred to responded to only one distinct alkaloidal test, namely, a yellowish-white amorphous precipitate with phosphomolybdic acid. When forwarding the plant materials, the local District surgeon stated that there was some uncertainty as to whether they were really derived from the same plant as that from which the decoction that had produced the fatal result was prepared. In cases such as this contradictory statements are very often made regarding the symptoms said to have been witnessed at the time—statements which are of necessity exceedingly confusing to the scientific investigator, the more so as the physiological action said to have been observed has generally to be accepted upon the hearsay evidence of unskilled persons.

I have alluded to Mr. Meiring's communication on the subject of the active principle contained in *Mesembrianthemum tortuosum*, L. The plant is known locally as Hottentot's Kouwgoed, and has a soporific effect. As was already pointed out by Pappe,* the natives are in the habit of chewing it, and become intoxicated. Mr. Meiring found this plant to contain an alkaloidal principle, and although he does not mention any characteristic colour reactions by which this alkaloid may be distinguished, he appears to have proved the alkaloidal nature of the substance by means of several reagents usually applied in such cases. I do not, however, find any mention of the fact that this plant contains an essential oil. Now, some years ago a case of poisoning which occurred near Worcester was submitted for investigation: the persons affected, two children, came home staggering, and suffering from irregular spasms, with great drowsiness. The pulse was small and very rapid, the pupil of the eye dilated and insensible except to severe stimulation.

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* Pappe, "Floræ Capensis Medicæ Prodromus," 2nd ed., 1857, p. 17.

Apomorphine hypodermically injected was used successfully as an emetic. Three hours after this treatment both showed distinct signs of recovery, but they still jerked spasmodically. Three hours later the patients were doing well. Mustard had also been used as an emetic, and to some extent its presence must have masked the reactions of any other active principle contained in the ejected material. Contrary, however, to Mr. Meiring's experience, no definite reactions were noticed on treating the different residues with the well-known alkaloidal reagents: on the other hand, a very small quantity of an essential oil, having a very characteristic peppermint-like odour, was isolated. Unfortunately there was far too little of the oil to enable any decisive statement to be made, but there was nevertheless a striking resemblance between it and an oil which apparently exists in the *Mesembrianthemum.* Mr. Meiring, by injecting his alkaloid into frogs, states that the effect is markedly narcotic. The question arises whether this plant does not contain two active principles, the physiological effects and chemical reactions of which differ.

It is well known that several allied poisonous principles frequently occur together in one plant: I need go no further than to mention the alkaloids of opium as instances of this, but the simultaneous occurrence of alkaloids and essential oils of this nature, and of alkaloids and glucosides, is more uncommon.

This brings me to mention a plant that has repeatedly been brought into prominence in connection with investigations into chemico-legal cases in the Colony: I allude to *Acocanthera venenata,* Don, Harvey's *Toxicophlæa Thunbergii.* To this plant I shall return at a later stage.

Unfortunately for the study of the physiological action of our indigenous plant poisons, in most of the cases the symptoms noted must receive allowance on account of the fact that the persons to whom the drugs have been administered were in a bad state of health. To take one instance: a Kaffir woman, in the Glen Grey district, aged between 50 and 60, was made to drink the powdered root of a certain plant mixed with water. The mixture produced an immediate emetic effect terminating fatally. Post-mortem examination showed that the deceased had suffered from valvular heart disease, enlargement of the liver, and general constitutional derangement. The ejected material was not forwarded for analysis, and the stomach itself, having been practically emptied, afforded little information as to the nature of the supposed poison. However, the tests applied produced the same reactions both in the stomach and in the roots which were supposed to be the direct cause of death. On account of the striking similarity thus noticed it was concluded that the stomach contained the same active principle as that in the root, and it was thus proved that the deceased woman had actually partaken of the root. Physiological experiments upon a dog and a guinea-pig with residues obtained both from the stomach and from the root extract were, however, entirely negative. The root, of which only a small quantity was sent to me, appeared to be a species of *Gomphocarpus*—according to Professor MacOwan it was an as yet undescribed *Asclepiad*—known by the Western Province farmers as Bitter wortel. Pappe* described "Bitter wortel," which he identified with *Gomphocarpus crispus*, R.Br., as extremely bitter and acrid, and said that on account of its diuretic properties it is used in cases of dropsy, and a tincture prepared from it is declared to be a valuable remedy for colic. It is by no means unlikely that even a dose of tepid water, not to speak of a hot infusion of the powdered root, may have produced emesis when taken on an empty stomach, and, in a case circumstanced as that under consideration, there is no wonder that a fatal result ensued. This by no means proves the poisonous nature of the plant, for, as already stated, physiological tests were entirely without effect.

A far more satisfactory examination, from a chemical point of view, was made in the case of the so-called "Quinine tree" of the Transkei, although in this instance I have, unfortunately, no physiological data to present. The tree I allude to is *Tabernæmontana ventricosa*, Hochst., and is known as Umjela by the natives. The bark of this tree, which flourishes in the Gxwaleni forest, in the Nyanduli district, has a bitter taste, and is reported to possess the well-known therapeutic properties of quinine. Only a small quantity of the bark was received, and as the district is rather remote it was not possible to procure any more at the time; the investigation was therefore of necessity restricted. No quinine was detected, nor was any other alkaloid of the cinchona group found; but from a chloroform solution, on evaporation, needle-shaped crystals were isolated, amounting quantitatively to nearly ·2 per cent. of the bark. On further examination this substance was found to be an alkaloid yielding the following reactions:—

Melting-point	About 200° C.
Taste	Bitter.
Reaction with litmus	Alkaline.

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* *Op. cit.*, p. 29.

Not fluorescent in acid solution	
Solubility	Very soluble in chloroform, alcohol, benzene, and also in very dilute sulphuric and hydrochloric acid.
Alkaline hydrates	Not precipitated from dilute solutions.
Alkaline carbonates	Not precipitated from dilute solutions.
Ammonia	Precipitate, insoluble in excess.
Picric Acid	Amorphous yellow precipitate.
Ferric chloride	No precipitate.
Platinum chloride	No precipitate.
Gold chloride	Crimson lake and gold reduced.
Potassium ferricyanide	Reduced to ferrocyanide.
Potassium sulphocyanide	Nil.
Chromic acid	Reddish-brown precipitate soluble in excess with reddish-vermilion colour.
Phosphomolybdic acid	Amorphous yellowish-white precipitate.
Phosphotungstic acid	White precipitate.
Iodo-potassium iodide	Amorphous red-brown precipitate.
Bismuth potassium iodide	Curdy brick-red precipitate.
Mercury potassium iodide	Curdy white precipitate, insoluble in excess and in alcohol.
Mercuric chloride	White precipitate.
Chlorine water (Thalleioquin test)	Reddish-brown colouration.
Bromine water	Reddish-brown colouration.
Concentrated sulphuric acid	Slight vermilion colour.
Concentrated sulphuric acid with sugar	Slight darkening.
Concentrated sulphuric acid with potassium dichromate	Light yellow.
Concentrated nitric acid	Brownish-red colour.
Fröhde's reagent	Dark blue changing into green.
Marmé's reagent	Curdy white precipitate.
Vitali's test	Beautiful crimson lake.

The last-mentioned reagent affords a very delicate test for this substance. As already remarked, there appears to be little doubt that it is a new alkaloid, but on account of insufficiency of material further tests could not be made. It is interesting to note that the tree attains a large size in the forest mentioned, and also in the Mpami forest, Elliotdale, specimens occurring 4 feet in diameter and 50 feet in height; the abundance of the tree should, moreover, render it possible, if the drug prove to be commercially valuable, to obtain it in large quantities.

In order to proceed with the research, a larger amount of the bark has since been obtained, and is now in the hands of Mr. J. Muller, B.A., the Government analyst in charge of the Laboratory at

Grahamstown, by whom the above investigation was conducted. It is hoped that some physiological tests may also be made.

The bulb commonly known amongst the Dutch-speaking portion of the inhabitants as "gift-bol," called "In-Cwadi" by the Kaffirs, and scientifically termed *Buphane toxicaria*, Herb., was examined in connection with the fatal poisoning of two Kaffir women. This plant is stated by Smith[*] to be used for the disease known as red-water in cattle. It grows on the Elandsberg in Tembuland and near King Williamstown, and Bushmen are reported to have used the bulb as an arrow-poison. This bulb, cut up, air-dried, and ground in a mill, was treated with absolute alcohol for several days and the filtrate evaporated; the residue so obtained, freed from all colouring and resinous matter, was dissolved in acidulated water. From this, by alkalisation and shaking up with a mixture of ether and chloroform, an uncrystallisable residue was obtained, which yielded very characteristic results with the usual alkaloidal reagents and solvents as detailed below:—

Solubility	Insoluble in distilled water; very soluble in alcohol, in chloroform, and in water slightly acidulated with hydrochloric or sulphuric acid; less soluble in ether or benzene.
Bromine water	Nil.
Ammonia and fixed alkalies	Precipitates.
Picric acid	Yellow precipitate.
Platinum chloride	White cloudy precipitate.
Gold chloride	White cloudy precipitate.
Phospho-tungstic acid	White precipitate.
Sonnenschein's reagent	Curdy white precipitate.
Wagner's reagent	Faintly violet precipitate changing into deep chocolate.
Fröhde's reagent	Permanganate violet colour, permanent.
Concentrated sulphuric acid	Permanganate violet colour, evanescent.
Concentrated sulphuric acid and potassium dichromate	Violet colour, almost immediately evanescent.
Concentrated nitric acid	Bright yellow colour.

The active principle appears to be an alkaloid, and is contained in the fresh bulb to the extent of nearly ·4 per cent., imparting to it a slightly bitter taste. One drop of the acidulated aqueous solution killed a young mouse in three minutes, a much larger mouse being killed by two drops in five minutes. The symptoms observed were—

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[*] "South African Materia Medica," 3rd ed., 1895, p. 158.

at first restlessness, then muscular twitchings, and finally alternating violent muscular contractions and relaxations. The hearts were found to be somewhat pale, but not contracted, and contained much blood. The liver was practically normal, though pale, and the intestines much contracted and twisted. An aqueous extract, representing 35 grains of the dried and powdered bulb, administered to a healthy dog seven months old, produced restlessness in fifteen minutes, excitement of the sensory nerves, considerable acceleration of the pulse, and clonic convulsions. Gradual recovery then took place, and on the day following the dog appeared quite well again. After two days another dose, equal to 80 grains of the dried bulb, was administered. Within ten minutes anxious restlessness ensued, followed by sudden shivering and muscular twitchings. Forty-five minutes after administration of the dose alternate paroxysms of convulsions and intervals of quiet succeeded, the dog seeming at times to be at the point of death from asphyxia through rigidity of the respiratory muscles. From this stage recovery gradually took place, health being apparently restored by the next day, although great weakness prevailed. A larger dose would doubtless have been fatal. The active principle contained in this bulb evidently belongs to the excito-motor class, herein resembling nux vomica. The alkaloid, if such it is, seems to present a closer similarity in its physiological action to brucine than to strychnine, differing, however, from both in its chemical reaction.

It must not be imagined that alkaloids and glucosides alone are poisonous of all the principles occurring in plants. I have already touched on the possibly toxic character of an essential oil which is present in *Mesembrianthemum tortuosum;* another case of this description was noticed in respect of an unknown root which was said to have caused the death of a native woman at Qumbu. The sender forwarded only the bare root—no leaves, flowers, fruit, or anything by which the plant could be identified. No alkaloid or glucoside was found, but the supposed poison was accounted for by the presence of a resin which formed about 1 per cent. of the root. This resin yielded the following reactions:—

Solubility	Soluble in 50 to 80 per cent. alcohol; slightly soluble in water.
Concentrated sulphuric acid	Dissolves with bright yellow colour, which is destroyed on addition of nitric acid.
Concentrated sulphuric acid with potassium dichromate	Fades to greenish-blue.
Fröhde's reagent	Bright yellow colour, permanent.
Concentrated nitric acid	Insoluble, discoloured.

Two mice were each given two drops of the resin extract, and died in three and five minutes respectively. Respiration was greatly retarded, and after death the hearts were found pale and firmly contracted, the left ventricles being practically empty. The liver, too, was pale. In a dog muscular tremors and a marked slowing of the heart-beat were the most prominent symptoms produced by about 60 grains of the powdered root; recovery was nevertheless complete by the following day.

The plant indigenous to this country to whose credit the largest number of poisoning cases must be placed is undoubtedly *Acocanthera venenata*, Don, to which reference has already been made. The Kaffir names of this plant are given by Smith * as Intlungunyembe or Ubuhlungu benyoka. In reporting on the probabilities of poisoning by *Acocanthera*, one is met by the difficulty that is experienced all along the line of South African drugs and poisons—the principle which the plant contains has not yet been fully investigated either chemically or physiologically. Physiologically it is known to act as a violent emetic and by powerfully contracting the muscle of the heart. Chemically there are no recorded tests for the presence of the Acocanthera poison. Smith † states that the active principle has been examined by Professor Fraser, but he records no chemical tests that could be applied to ascertain its presence. The only Acocanthera mentioned by Sohn ‡ is *Acocanthera Ouabais*, the poison of which appears to differ from that under consideration; but it is worth noting that the poisonous principles of this plant, namely, ouabain and strophanthin, are also said to cause the rapid arrest of the heart in systole.§ In the *Pharmaceutical Journal* ‖ Gerrard deals with the African (Wa-Nyika) arrow-poison, and identifies it with strophanthin. Amongst other conclusions mentioned, he declares it to be a powerful heart-poison, arresting the ventricle in systole. He also adds—and I shall have to refer to this point later—the following observation: "The antidote is stated to be made from five roots; . . . to prepare the antidote the roots are converted into charcoal, which is coarsely powdered." A paper has been published by Fraser and Tillie,¶ communicated to the Royal Society, giving further information respecting the Wa-Nyika arrow-poison; they place the poison in the genus Acocanthera (possibly *Acocanthera Schimperi*), at the same time confirming what had already been published regarding its action on the heart. The authors mention one characteristic chemical test, namely, that when crystals of the purified poison, which they consider to be a glucoside, are treated with strong sulphuric acid, a pink colour is almost immediately developed, which soon darkens to a brick-red, and then slowly fades to a pale brown. The subject is still further enlarged upon by Holmes.* He likewise considers the Wa-Nyika poison to be derived from an Acocanthera, and then goes on to refer to the Swahili arrow-poison, which he says is certainly derived from an Acocanthera, but is doubtful whether the plant is *Acocanthera venenata* or *Acocanthera spectabilis*.

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* "South African Materia Medica," 3rd ed., p. 37.

† *Op. cit.*, p. 38.

‡ "Dictionary of Active Principles of Plants," p. 93.

§ Allen, "Commercial Organic Analysis," 1896, vol. iii., pt. iii., p. 140.

‖ *Pharm. Journ.*, vol. xi., pp. 833 to 835.

¶ *Pharm. Journ.*, vol. xxiv., pp. 41, 42.

It will be seen from what I have already said that the identity of the plant has been somewhat uncertain, and the only chemical test recorded is the isolated one mentioned by Fraser, which may possibly be found to apply to all the Acocanthera poisons, or only to that found in *Acocanthera Schimperi*.

The point I wish to emphasise is this—that hitherto there has been no recognised well-defined chemical test for any of the Acocanthera poisons, and certainly not for the poison of *Acocanthera venenata*. The position to be faced by an analyst, who has to test for this poison in human organs, differs therefore widely from that which he has to occupy when testing for strychnine, or arsenic, or any of the well-known poisons, the tests for which are subjects of general scientific knowledge: in such cases as the latter one needs but to apply those recorded tests, and, from the reactions noticed, infer the presence or absence of the poison he is in search of. With regard to Acocanthera there were no such recorded tests; they had to be discovered ere they could be applied, and to the analyst engaged in elucidating the mysteries of a case of culpable homicide, the time allowed for coming to a conclusion is hardly adequate for the pursuance of lengthy original research. Hence the scientific knowledge necessary for expert judgment comes to us piecemeal as case follows case.

One of the earliest cases of evident Acocanthera poisoning to come under my notice occurred about four years ago. It was that of a Kaffir woman, apparently 60 or 65 years of age. Half a cupful of a plant decoction had been administered to her, and fifteen minutes later she was found dead, vomiting and purging having taken place meanwhile. Post-mortem examination revealed the fact that she had been affected with fatty degeneration of the heart, while the bases of both lungs were congested. The District Surgeon who performed the autopsy, concluded that fatal syncope had been brought about by the strain of vomiting and purging, acting upon a heart already weakened by disease. The leaves and bark from which the decoction was made were identified as *Acocanthera venenata*, Don. A hurried examination of the small quantity of leaves and bark received failed to show the presence of any alkaloid, and even a fairly concentrated decoction prepared in our laboratory had no effect whatever on guinea-pigs; but when 10 to 15 c.c. of a 20 per cent. decoction of the plant were given to a dog, vomiting took place within ten minutes, accompanied by very severe and continuous straining, the animal, however, eventually recovering completely. The decoction received from the District Surgeon had the same respective effects when administered to the guinea-pig and dog, although the action on the dog was less violent, owing to the latter decoction being of a less concentrated strength.

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* *Pharm. Journ.*, vol. xxiv., pp. 41, 42.

These results, incomplete as they were, showed that the plant contained an active principle of violent action, and that, when administered to any one suffering from a weak heart, fatal consequences might ensue. It was concluded from the peculiar action of the plant, and its bitter taste, that it probably contained a glucoside possessing very violent emetic properties, emesis being accompanied by severe straining, and apparently affecting carnivorous animals more seriously than those which are herbivorous.

Both the physiological and the chemical tests disproved the assertion made in the earlier editions of Smith's "South African Materia Medica," that the plant contains the alkaloid brucine—a substance which yields quite distinct chemical reactions, and also produces totally different symptoms when administered.

A year later I received from Glen Grey the stomach of a child who had died, according to the District Surgeon's testimony, of peritonitis, which, he said, could have been caused by an irritant poison. It appeared that the child—she was eleven years old—having been ill, a Kaffir "medicine-man" administered some decoction to her as well as to other members of the family. In each case vomiting and purging resulted. The child is said to have vomited three times, after which she fell down and expired almost immediately. Two small parcels containing parts of plants were forwarded for analysis, but there did not appear to be any positive evidence to connect them with the decoction administered to the child. On arrival in the laboratory the stomach was found to be practically empty. The spirits of wine in which it had been preserved was seen to possess a brilliant green tint, due, as afterwards discovered, to chlorophyll. By repeated shaking of the alcoholic extract with chloroform and ether in turn a substance was obtained which yielded the following results with some of the well-known tests for alkaloids:—

Picric Acid	Yellowish-white precipitate.
Phospho-molybdic Acid	Curdy-white precipitate.
Scheibler's reagent	Amorphous white precipitate.
Wagner's reagent	Slight red precipitate.
Mayer's reagent	White precipitate.
Marmé's reagent	White precipitate.
Dragendorff's reagent	Slight red precipitate.
Gold chloride	Faint precipitate.
Platinum chloride	Whitish flocculent precipitate.

Some of this chloroform residue was given to a dog and produced emesis within seven minutes. The amount, however, of the active principle which was left in the stomach and in the portion of the liquid subsequently given to the dog must have been very minute, seeing that the child had vomited three times before death. Decoctions of the packets of plant material received were prepared and administered to the dog in fairly large doses without any effect: apparently, therefore, they did not contain the plant used by the "Kaffir doctor." Judging from the physiological effects produced on the deceased child, and from the results of the analysis, it was surmised that the drug used may have been *Acocanthera venenata.* Here again it was a pity that the ejected matter had not been preserved for analysis, nor the condition of the deceased's heart noted.

Another year passed ere a further case of similar nature afforded an opportunity for further progress. To a native child, at Glen Grey, who was, to all appearances in good health, a "Kaffir doctor" was for some obscure reason called in by the mother. The "doctor" administered a drug which caused speedy death. The post-mortem examination revealed the fact that death was apparently due to the arrest of the heart in systole. My attention was by this circumstance at once directed to Acocanthera, the plant being well known in the district, and reported to act precisely in the way described, the effect on the heart being powerfully contractive. Similar cases are recorded by Smith,* who also mentions Fraser's description of the manner in which this action on the muscle of the heart is caused by the plant.†

This was the first instance that had come under my notice, in which the circumstances of death clearly pointed in the direction of poisoning by Acocanthera: in nearly every previous case there had been flaws in the chain of evidence, partially owing to the fact that the poison was practically new to science. Although the physiological action appeared to be the same, up to that time there had been no definite tests capable of application, so as to identify the poison found in the organs with that contained in the plant. In the interval, however, that had elapsed between the submission of this case and the one previous I had determined to make at least some endeavour in the direction of investigating the matter more thoroughly. Through the kindness of Mr. H. G. Flanagan, of Komgha, I was enabled to procure a supply of *Acocanthera venenata*. The investigation was naturally one that needed abundance of time and leisure, which I was not able to bestow on it, but I succeeded in doing what I think will enable the poison to be identified in most cases that may hereafter occur.

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* "South African Materia Medica," 3rd ed., p. 38.

† *Op. cit.*, p. 39.

The results of my investigations were these.

If the root and bark of *Acocanthera venenata* are ground and treated with alcohol, and the alcoholic extract purified by means of charcoal, and evaporated, an active principle is obtained responding to the following chemical tests :—

Fröhde's reagent	Yellowish - brown changing into brownish-green.
Concentrated sulphuric acid	Yellow, changing first to pink, then brick-red, and finally violet.
Concentrated sulphuric acid with potassium dichromate	Emerald-green changing into clear blue.

A strong and healthy mouse treated with a very small quantity of the residue of the alcoholic extract just mentioned died in 20 hours; the heart was found, by post-mortem examination, to be very firmly contracted, and the small intestines and liver congested. A young mouse similarly treated also died, but in this case no post-mortem examination was made.

In the stomach of the last-mentioned child the above-named characteristic reactions were also noticed, but the quantity of the posion was too small for exact determination; it was probable, however, that some of it had been lost by emesis and some absorbed into the system, as it is evident that the drug is one capable of very rapid absorption.

A sample of the root forwarded together with the child's stomach was extracted in a similar manner and administered to a healthy and vigorous mouse, which died within a few hours; the heart was quite contracted, pale and firm. To another mouse, which had apparently been previously injured, a small quantity of the drug was also given. In this case, too, death ensued, but the heart was found to be only slightly contracted, death having apparently been hastened by the injury referred to. A third mouse, treated in the same way, lived for 30 hours; in this case also the heart was found to be firmly contracted. Two other mice, similarly treated, likewise succumbed, but no post-mortem examinations were made.

I alluded to Gerrard's mention of the use of charcoal as an antidote by the natives: in this connection it was curious to note that on the person of the Kaffir doctor who was connected with the last case was found a black powder consisting of oxide of copper together with minute crystals of copper sulphate mixed with powdered charcoal.

From the tin out of which the deceased drank the decoction, after extraction with alcohol, a residue was obtained exhibiting the chemical reactions before mentioned. This extract also caused the death of a mouse in a few hours, the heart being found pale in colour at the apex and very firmly contracted, while the small intestines were slightly congested.

About two years ago four ounces of the contents of a stomach of a native woman were analysed by Mr. J. Muller, B.A., the analyst in charge of the Grahamstown branch of our laboratory. The fluid was treated with pure alcohol for some days and the clear filtrate evaporated. Mr. Muller's investigations showed the extract to contain an uncrystallisable substance, very soluble in alcohol, chloroform, and acidulated water, but insoluble in ether. The tests applied produced results which were recorded as follows by Mr. Muller:—

Concentrated sulphuric acid	Pink colour, deepening to brick, then passing into chocolate-brown, bluish-green, and violet.
Concentrated sulphuric acid, with potassium dichromate..........	Greenish-yellow and emerald-green.

In the post-mortem examination on the deceased it was recorded that all the organs were normal, but the heart bloodless.

The extract obtained from the stomach by methods already detailed were administered to mice, one drop of the extract being given to each; one of the mice died in 32 hours, the others in 34 and 36 hours respectively. To the last two a second drop was given 24 hours after the first. The symptoms produced were tonic contraction of the muscles, slowing and intermittence of the respiration, gaping accompanied by a straining movement like that of vomiting. Before final arrest of the heart a slowing is noticeable, due to increase of the systolic contraction and lessening of the diastolic expansion. Apparently the cessation of respiration takes place after arrest of the heart.

In each case all organs except the heart appeared normal. The latter organ was removed and embedded in paraffin blocks, sections of which have been made for examination under a low power of the microscope.

It may here be noted that the wood of *Acocanthera venenata* contains about ·33 per cent. of the active principle. We have as yet no data upon which to calculate the minimum fatal dose of this plant, although Smith * records that 15 grains of the dried leaves is the largest safe dose, but as regards *Acocanthera Schimperi* Fraser and Tillie † state that by sub-cutaneous injection the minimum lethal dose of Acocantherin is $\frac{1}{500}$ to $\frac{1}{400}$ of a grain per lb. weight of a rabbit, from which it may be assumed that, for an average man, $\frac{1}{4}$ to $\frac{1}{3}$ of a grain of the purified Acocantherin may be fatal.

The contraction of the heart that I have repeatedly alluded to is very characteristic in Acocanthera poisoning, and as soon as I became alive to this fact I suggested that the importance of recording the condition of the heart at post-mortem examinations should be impressed on District Surgeons in the part of the Colony where Acocanthera flourishes. It had been of frequent occurrence that where the heart was not organically diseased no remarks were made about its condition; an important link in the investigation may thus be missed. This point, I am glad to say, is now being attended to.

In a case which appeared in 1903 at Butterworth, a native woman died from the effects of administration of a root by a Kaffir medicine-man: the post-mortem examination showed that paralysis of the heart in systole had occurred, and the fine shreds of the root, examined in the Grahamstown Laboratory, exhibited the characteristic reaction for Acocanthera when treated with sulphuric acid, light pink, gradually becoming violet. A decoction was made from 15 grains of the powdered root, and half an ounce of this was administered to a healthy dog, eight months old. Repeated emesis occurred within 20 minutes, accompanied by violent straining and abnormal increase of secretion of saliva, such as is always noticed when this drug is administered to dogs. These symptoms were accompanied by great muscular weakness and tremors, apparent giddiness, retarded pulse and respiration. The emetic effects ceased after two hours, an hour later distinct signs of recovery were noticeable, and soon after this the dog was able to eat, food having remained beside it throughout. Two hours later the animal was to all intents and purposes quite well again.

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* "South African Materia Medica," 3rd ed., p. 38.

† "*Acokanthera Schimperi:* Its Natural History, Chemistry, and Pharmacology."

Another very energetic poison, probably a glucoside, was found in an unidentified bulb said to have caused the death of a native woman at Tsolo. The symptoms in the case of dogs and mice to some extent resembled those produced by Acocanthera; the mice dying in 10 to 40 minutes, the stomach and intestines becoming greatly distended, and inflamed in parts, the heart contracted, the left ventricle bloodless, and the lungs gorged with blood: the most characteristic appearance seemed to be that of the liver, which is much softened and becomes greatly congested. The active principle was obtained from the bulb by evaporating an aqueous solution of an acidulated alcoholic extract, rendering the residue alkaline and dissolving out with ether. The substance thus obtained was characterised by the following properties:—

Taste	Bitter.
Solubility	Soluble in water (especially if acidulated), also in alcohol, less soluble in chloroform and ether.
Concentrated sulphuric acid	Cherry-red; changing to lake and then to light pink.
Sulphuric acid with potassium dichromate	Yellowish-brown, changing first to green and then to blue.
Sulphuric acid with bromine	Yellowish-brown, changing first to green and then to blue.
Nitric acid	Nil.
Platinum chloride	Nil.
Gold chloride....................	Nil.
Molybdic acid	Nil.
Vitali's test	Nil.
Sonnenschein's reagent	White precipitate.
Scheibler's reagent	White precipitate.
Lead acetate	Precipitate.
Tannin	Precipitate.

In another poisoning case strips of bark and stem were submitted, portions of which had caused the death of a native at Nqamakwe. Here, as in the case last quoted, no leaves or flowers were received, and, owing to this omission, the plant could not be identified, which was most regrettable, as the chemical and physiological tests were very pronounced. The active principle was evidently a non-crystallisable glucoside, acting on the heart and arresting its action, generally in systole, but apparently also in diastole. The following results were observed on applying the customary tests to the principle extracted by alcohol:—

Taste	Slightly bitter.
Concentrated sulphuric acid	Bright vermilion, changing to orange, then yellow, and finally greenish-yellow.
Sonnenschein's reagent	White precipitate.
Platinum chloride	Nil.
Gold chloride	Nil.
Picric acid	Nil.

One drop of a 4 per cent. decoction of the powdered bark, administered to a mouse, resulted fatally in 10 hours; a drop of the aqueous solution of an alcoholic extract of the bark caused death in the case of another mouse in 10 minutes; a third mouse died 5 minutes after receiving a drop of an aqueous solution of the purified active principle, equivalent to one-fortieth of a milligramme of the latter. In all these cases the liver was pale and the stomach and intestines distended. The heart of the second mouse was arrested in diastole, and in the other two cases in systole. Too long boiling destroys the activity of this substance, but a carefully prepared decoction, in small doses, acts as a powerful emetic, and an overdose, as already stated, causes paralysis of the heart.

Certain roots which could not be identified caused the death of a native at Herschel. Chemical investigation showed no alkaloids or glucosides to be present, the toxic principle being apparently a resin. A decoction representing 4·6 grains of the root administered to a guinea-pig caused convulsions and loss of power in the limbs in a couple of hours, which terminated fatally 4½ hours after the decoction was taken. A decoction equivalent to 12·3 grains was given to a dog and the æsophagus was tied to prevent emesis; death occurred in 45 minutes. In both cases there was congestion of the stomach and upper portions of the intestines. Some medicine, prepared by the native medicine-man charged with the fatality, and forwarded at the same time, was administered to a guinea-pig (30 c.c., concentrated by evaporation to 3 c.c., were actually given in two doses an hour apart); similar symptoms were noticed as in the former case, and death ensued in 8 hours from the time of administration of the first dose. 75 c.c. were given to a rabbit in two doses separated by an interval of 3 hours; 90 minutes later paralysis of the after-extremities set in and gradually increased, terminating fatally.

In connection with the death of a native girl at King William's Town, a "Kaffir doctor" who had administered a decoction of certain roots to the deceased was indicted for culpable homicide. The plant was identified as belonging to the genus Polygonum, probably *Polygonum tomentosum, var. glabrum.* The plant is stated to be used by the natives as a remedy for black gall-sickness. From the plant, by means of alcohol, an acrid resin was extracted, which yielded the following colour reactions with strong sulphuric acid: bright pink to cherry-red colour, changing gradually through a deep lake to a dirty brown, and ultimately fading to a greenish tint. Doses of extract from the powdered plant were administered to three mice with the following results :—

Quantity of Plant represented by dose.	Period within which death occurred.
Three-fifths of a grain	Four hours.
Three-fourths of a grain	Two hours.
Four-fifths of a grain	One hour.

In each case the symptoms were very similar: uneasiness within 10 minutes, breathing at first very rapid but soon succeeded by pronounced intermittence of respiration, gaping and straining as if preparatory to emesis; the resin appeared to act as a strong depressant. After death the hearts were found to be pale; in two cases the left ventricle was firmly contracted, whereas in the third the right ventricle was contracted and contained very little blood; the stomachs and intestines were distended. A quantity of infusion equivalent to 8 grains of the powdered plant was given to a dog without any noticeable effect being produced.

Through insufficiency of material no further experiments could be carried out, but it appeared probable that the resin, present to the extent of nearly 2½ per cent. in the dried root, was the active principle that caused the fatality. It appeared likely that when given in toxic doses the drug would eventually paralyse the heart muscle and arrest that organ in systole.

I have alluded to some of the practical difficulties occurring in connection with investigations of the class that forms the subject of these notes; in addition to these, other circumstances are constantly coming to light which show that much more care and discrimination require to be exercised in selecting and submitting for analysis samples connected with matters of such grave importance. Bottles are so badly packed and sealed that loss, total or partial, of liquid contents, in transmission, is not infrequent; besides this, articles are often sent for analysis at haphazard, without circumspection, and very carelessly dealt with. In one case of alleged attempted poisoning it was asserted that snake-poison had been employed as the agent: in proof hereof a dead snake, said to have been found near the scene of the outrage, was packed in a small box and forwarded to the Government Laboratory, the sender going so far as to state in all seriousness the name under which this particular species of snake was known to the natives. On opening the box the "snake" was found to be nothing more than a piece of round, plaited, mud-encrusted stay-lace. On another occasion a dead human body was found, and poisoning was suspected. It was thought that, either by vomiting or by decomposition of internal organs, the poison could have got on to the clothing. The waistcoat was forwarded for analysis, but not the coat—which would have been the more likely to have shown traces of vomiting—nor the vest, which would first have been affected by poisons escaping from the internal organs. A bottle found near the spot, which might have contained the poison, was first used to fetch water for the purpose of washing the hands of certain officials present, and then only was it sent in for analysis.

In conclusion, I must express my deep consciousness of the exceedingly cursory nature of the examinations I have recounted, but as long as such work has to be undertaken under present conditions the results cannot be otherwise than tentative and incomplete. It is one of my greatest regrets that the exigencies and varied nature of the work under my charge constitute a permanent obstacle to detailing any analyst for the special duty of a thorough research into the subject of South African plant-poisons. A former Colonial Secretary, a physician by profession, once expressed to me his view that before anything else provision should be made for systematic research of this nature, and that it ought to be one of the recognised functions of the Government Analytical Laboratory to carry out such research. I cordially endorse the view, and trust that as soon as ever the depressed condition of the Colony's finances admit of the expenditure, the necessary provision for the performance of this important work may be made.

CONTRIBUTIONS TO THE AFRICAN FLORA.

By Harry Bolus, D.Sc., F.L.S.

(Read May 31, 1905.)

Muraltia spicata, Bolus, n. sp. (Polygalaceæ-Polygaleæ).

M. (§ Eumuraltia-Gymnocarpæ Chodat) *petalis ligulatis obtusis; carina basi unguiculata, lobis expansis subreniformibus, petala excedens; capsula obovata, apice pilosa ciliataque, cornubus capsula æquilongis; seminibus glabris vel parcissime pubescentibus.*

Fruticulus erectus virgatus, 1–1½-pedalis; rami pauci sæpius simplices, erecti, teretes, foliosi, cum foliis molliter albo-pilosi; folia sessilia, erectiuscula, pleraque imbricantia, anguste oblongâ, rarius oblanceolata, subobtusa, supra canaliculata, dorso carinata, crassa, minute tuberculato-rugosa, 0·7–1·2 cm. longa, 0·1–0·18 lata; flores spicati, inter majores; spica interrupta, 3·5–10 cm. longa, 1–1·4 cm. lata; sepala oblonga, lanceolatave, acuta, concava, glabra, subcarinata, leviter nervosa, 0·4–0·5 cm. longa; petala lateralia erecta, unguiculata, usque ad medium coalita, sursum libera ligulata obtusa, intus medio pilosa, 0·65 cm. longa; carina 0·8 cm. longa, e basi unguiculata sursum in lobos subreniformes 0·5 cm. longos, 0·3 cm. latos expansa, petala paullo excedens; capsula obovata, ciliata, apice pilosa, cornubus capsula subæquilongis, tota 0·5 cm. longa; semina glabra vel parcissime pubescentia cum pilis paucis sparsa.

Hab.: Cape Colony, South-western Region, district Bredasdorp, on hills near the mission station of Elim, alt. 300 ft., July, *Bolus* 8468; mountains towards Napier, 800 ft., *Guthrie*, 3767! hills near Koude River, 400 ft., April, *Schlechter*, 10468!

Distinct by its slender virgate habit, and rather large flowers. It seems to be nearest to *M. thymifolia*, Thunb.

Psoralea biovulata, Bolus, n. sp. (Leguminosæ-Galegeæ).

Ps. ovario biovulato distincta, etiamque exstipulata.

Fruticulus gracilis, decumbens, ramosus; rami ramulique patentes, gracillimi, angulati, paucifoliati, 30–50 cm. longi, juniores albosericei demum glabrescentes; folia exstipulata, remota, rigida, appressa vel erecto-patentia, lineari-subulata, acuminata, 0·2–0·3 cm. longa, marginibus incurvis, superne albo-sericea, subtus glabra; flores 1–3, in ramulis divaricatis brevibus, sæpius terminales, geminatique, rarius subracemosi; pedicelli 0·1–0·2 cm. longi; bractea subulata, colorata, æquilonga; calyx turbinatus, externe albo-sericeus, minutissime glanduloso-vittatus, 0·4 cm. longus, segmentis binis posterioribus alte connatis, ceteris alte fissis lancolatis acuminatis, tubo 2–3-plo longioribus; vexillum reniforme, emarginatum, unguiculo brevi, 0·6 cm. longum; alæ obovatæ, auriculatæ, vexillum paullo superantes; carina obtusa, basi auriculata, calcarata, vexillo paullo brevior; ovarium lanceolatum albo-sericeum, 2-ovulatum.

HAB.: Cape Colony; South-western Region, Bredasdorp district, between Elim and Napier, amongst shrubs, flowering in October, *Bolus*, 6902.

An interesting species differing from the usual generic characters by its 2-ovuled ovary, and the absence of stipules. The translucent glandular dots are very minute, but may be detected on the calyx. It may be placed next to *E. tenuissima*, E. Mey., from which it is at once distinguishable (besides the characters given above) by its very short pedicels.

LICHTENSTEINIA KOLBEANA, Bolus, n. sp. (Umbelliferæ-Apioideæ-Ammineæ).

L. foliis circumscriptione oblongis ovato-lanceolatisve bipinnatipartitis, pinnulis iterum incisis grosse dentatisve; fructibus compresso-globosis.

Herba perennis, glabra 1½–3½-pedalis; radices primariæ 3–4, parte indivisa ad 22 decim. longa vel ultra, 0·8 cm. crassa; caulis erectus validus sulcato-striatus, infra medium ramosus, subnudus, bracteis 2–3, parvis, membranaceis, sursum foliaceis, pinnatipartitis, donatus; rami 3–4, subfastigiato-corymbosi, apice umbelliferi; folia radicalia 4–6, procumbentia vel laxe adscendentia, 7–27 cm. longa, 4–12 cm. lata, petiolis dilatatis striatis subamplexicaulibus, 2–6·4 cm. longis, ad 1 cm. latis, lamina circumscriptione oblonga ovato-lanceolatave, bipinnatipartita, pinnis 4–6-jugis, pinnatifidis, secundum rhachin longe alato-decurrentibus incisisque, pinnulis oblongis acutis 1·5–3 cm. longis, incisis grosse dentatisve basi late decurrentibus; umbellæ 9–13-radiatæ, pedunculis fructiferis ad 6·5 cm. longis, bracteis 5–6, linearibus acuminatis 1–1·5 cm. longis; umbellulæ 8–15-radiatæ, pedicellis fructiferis 0·8–1 cm. longis, bracteis 5–6; petala basi unguiculata, lamina elliptica, apice arcte deflexa longe acuminata, basin fere attingentia; fructus maturus subcompresso-globosus, (siccitate?) rugulosus, atro-brunneus, 0·4 cm. longus et latus; carpophora bipartita pallida (ceteris generis).

Hab.: Cape Colony (South-eastern Region), district Kentani, amongst grass (*Erianthus capensis*, Nees), alt. about 1,000 ft., fl. Dec., *Miss A. Pegler*, No. 891! (in herbb. Kew, Berlin and my own).

Distinct by its much divided leaves and large spreading inflorescence. The species is dedicated to the Rev. F. C. Kolbe, D.D., of Cape Town, who has distinguished himself by his love of Cape botany, and his enthusiastic efforts in teaching and spreading a love for it amongst others.

Felicia maritima, Bolus, n. sp. (Compositæ-Asteroideæ).

F. foliis alternis, semiteretibus, carnosis; capitulis terminalibus, solitariis, 40-*floris; involucro 3-seriato; achæniis hispidulis.*

Herba salsuginosa, humilis, decumbens; rami graciles e caudice, nunc adscendentes, nunc patentes, nodiis radicantes, glabri vel hispiduli; folia alterna subpauca, adscendentia, e basi dilatata semiamplexicaulique scariosa, lineari-semiteretia vel filiformia, obtusa, carnosa, 0·15–0·35 cm. longa, 0·07–0·12 cm. crassa; capitula terminalia, solitaria, turbinata, 0·5 cm. longa, 0·4 cm. diam.; involucrum 3-seriatum, squamis oblongis vel oblongo-lanceolatis, acutis, intimis longioribus, floribus paullo brevioribus; flores radii circ. 14, ligulis albis; flores disci circ. 25, flavi; achænia hispidula, pappi setis subpaucis, barbellatis.

Hab.: Cape Colony, in sandy ground near the sea-shore, inundated in winter, Maitland, near Cape Town, fl. June, coll. *A. Bolus* (Herb. Norm. Austr.-Afr., 1170; herb. Bolus, 6265!).

Allied to *F. ficoidea*, DC. (also a halophilous plant), but quite distinct by its slender habit, alternate, obtuse, narrower leaves, and acute involucral bracts.

Felicia Flanaganii, Bolus, n. sp. (Compositæ-Asteroideæ).

F. foliis oppositis, petiolatis, ellipticis, ovatisve, integris; pedunculis monocephalis; involucro 1-*seriato, squamis pilosis; floribus radii* 12, *ligulis albis, disci ad* 33, *flavis; achæniis hispidulis; pappo* 1-*seriato.*

Fruticulus procumbens, vel dependens, ramosus, ad 25 cm. longus; rami oppositi, graciles, pubescentes, pallidi, in pedunculo monocephalo, nudo, pubescente, pallido, pleroque 8–12 cm. longo, desinentes; folia patentia, opposita, petiolata, petiolo 0·3–0·5 cm. longo, lamina elliptica, ovatave, obtusa, obscure apiculata, submembranacea, pilosa, supra viridia, subtus pallidiora, 0·8–1·2 cm. longa; capitula turbinata, 0·8–0·9 cm. longa, 0·9–1·1 cm. lata, receptaculo alveolato; involucrum 1-seriatum, squamis circ. 12–13, oblongis, linearibusve, acutis, nervatis, pilosis, pallescentibus, floribus paullo brevioribus; flores radii circ. 12, ligulis albis apice 3-dentatis, flores disci circ. 33, flavi; achænia hispidula, pappo 1-seriato, subcopioso, setis barbellatis.

Hab.: Cape Colony, South-eastern Region, district Komgha Mooi Plaats, overhanging precipitous rocks, alt. 1,000 ft., June, "not common," *Flanagan*, 1799!

Allied to and with the habit of *F.* (*Aster petiolatus*, Harv. Thes. Cap. t. 154), but distinct by its opposite, entire leaves; also near to the south-western *F. brachyglossa*, Cass. (*Aster Cymbalariæ*, Thunb.), but the habit differs, as well as the leaves, and the longer peduncles.

GYMNOSTEPHIUM LEVE, Bolus, n. sp. (Compositæ-Asteroideæ).

G. foliis alternis, linearibus; involucris 4-serialibus, serie interiori e squamis 13 condita; floribus radii circ. 14 lilacinis, pappo pleroque carentibus; floribus disci flavis, plerisque sterilibus; pappo e setis paucis barbellatis.

Fruticulus gracillimus, erectus, fere totus glaber, 1–1½-pedalis; caules plerique simplices rarius basi semel ramosi, leves, pallidi; folia alterna, sparsa, linearia, subacuta, subtus 1-nerva, parte inferiori ciliata dilatata semi-amplexicaulia, 2–3·5 cm. longa, vix 0·1 cm. lata; pedunculi subnudi 10–12 cm. longi; bracteis 2–3, remotis, foliaceis, minimis, præditi; capitula turbinata vel cyathiformia, 0·85 cm. longa, apice 0·95 cm. lata; involucrum 4-seriale, serie interiori e squamis 13, cuneato-oblongis, obtusis, levibus, flavescentibus, obscure nervatis, parce ciliatis, condita, ceteris paucioribus subsimilibus, brevioribus; receptaculum alveolatum; flores radii circ. 14, ligulis oblongis, tridentatis, lilacinis, circ. 0·7 cm. longis, achæniis levibus, glabris, pallidis, pappo pleroque carentibus, vel rarius setis 2–3 coronatis; flores disci circ. 50, flavi, plerique steriles, casu tamen rarissime unus alterusve fertiles, pappo e setis paucis barbellatis.

Hab.: Cape Colony, district Ceres, in moist grassy or marshy places at the Gydouw, alt. 3,100 ft., Dec.–Jan., *Bolus*, 8625! Herb. Norm. Austr. Afr. 1169! Koude Bokkeveld Mountains near Tandfontein, 4,500 ft., Jan., *Schlechter*, 10141!

LEYSSERA MONTANA, Bolus, n. sp. (Compositæ-Inuloideæ).

L. acaulescente; pedunculis monocephalis; capitulis campanulatis; involucri bracteis 5–6-seriatis; receptaculis epaleaceis foveo-

latis ; radii floribus 20–24, *disci* ∞ ; *pappo e setis barbellatis* 11–15, *corollæ tubum æquantibus, paleis brevibus intermixtis.*

Fruticulus humillimus, acaulescens? (specimen unicum caudice carptum ut videtur nec radices ostendit), totus cum pedunculo 9 cm. altus; rami (duo, in exempl. nostr.) lignosi, dense foliosi, circ. 2 cm. longi; folia numerosissima, dense conferta, totum caulem obtegentia, patentia, oblongo-spathulata, obtusa, basin versus angustata, subsessilia, 1·3–1·8 cm. longa, sub apice 0·2 cm. lata, subtus obscure nervata, lana densa alba, intertexta, omnino vestita; pedunculi graciles, monocephali, pilis floccosis, minimis, paucis, 6 cm. longi; capitula campanulata, 1·3 cm. longa, 1·6 cm. diam., involucrum 5–6-seriatum, bracteis numerosis, erectis, appressis, planis, oblongis, anguste ellipticisve apice angustatis obtusiusculis, scariosis, exterioribus sensim brevioribus; receptaculum epaleaceum, foveolatum; flores radii 20–24, flavi, ligulis oblongis, obtuse 3-dentatis, pappo 2-seriato e setis 11–15, longis, barbellatis, corollæ tubum æquantibus cum paleis brevibus intermixtis, achæniis dense pilosis; flores disci flavi, ∞, pappo achæniisque, ut in ♀.

HAB.: Cape Colony, South-western region, district Worcester, on the Matroosberg, alt. circ. 6,500 ft., fl. Jan., *A. Bolus* (6367! in my herb.).

This species is interesting as an example of a mountain form, or of what is often called an "Alpine" form (an objectionable term, as I venture to think, because of its ambiguity as leading to a possible conception of the Alps of Europe). While very near its congeners in general structure, it is completely different in habit from them all. On the same mountain (the loftiest in the South-western region of South Africa, and attaining a height of 7,400 ft.), several other plants of a similar habit have recently been found by Dr. R. Marloth, who has published an interesting paper on them in the *Transactions* of this Society, vol. xi., part 3, pp. 161–168, with several illustrations. One of the species figured (*Felicia bellidioides*, Schltr.), though a herb, very much resembles the present species in habit. I have but one specimen of the latter, which seems to have been broken off just above the collar.

PHYMASPERMUM APPRESSUM, Bolus, n. sp. (Compositæ-Anthemideæ).

Ph. foliis arcte appressis, ovatis, cuspidatis, minimis ; capitulis terminalibus, hemisphæricis ; involucri squamis 4-*serialibus, glabris ; receptaculo convexo ; floribus radii* 10–14, *disci* 40–50.

Suffrutex erectus, ramosus, 2–4-pedalis; rami adscendentes, tenues, foliosi, nervis foliorum decurrentibus striati, tomentosi,

inferioribus sterilibus, abbreviatis, 0·7–1·5 cm. longis, foliis imbricatis dense vestitis, superioribus florigeris elongatis, 5–10 cm. longis, foliis remotioribus usque ad basin capitulorum; folia sparsa saepe gemmifera, sessilia, appressa, ovata, crassa, glabra, nitida, juniora acuta, vetustiora demum longe cuspidato-acuminata, 0·2–0·4 cm. longa, cuspidibus membranaceis, setiformibus, brunneis, laminam aequantibus vel excedentibus, subtus 3-nerva, nervo medio prominente, incrassato, longe decurrente, nervis lateralibus nunc obscuris nunc etiam incrassatis decurrentibusque; capitula in ramulis superioribus nunc brevibus nunc elongatis, terminalia, solitaria, corymbos irregulares laxos mentientia; involucrum hemisphæricum, squamis erectis, imbricatis, 4-serialibus, glabris, siccis, rigide papyraceis, pallidis, exterioribus brevioribus, ovatis, subobtusis, carinatis, interioribus oblongis, basi calyculatum, 0·7–0·8 cm. longum et latum; receptaculum convexum, pilis brevissimis articulatis parce sparsum; flores radii 1-seriales, circa 10–14, ligulis oblongis albis, 0·7 cm. longis; fl. disci ☿, ca. 45–50, 5-lobi, tubo glanduligero, flavi, 0·3 cm. longi, styli truncati, breviter ciliolati fimbriative; achænia cylindrica, 10-costulata, glandulosa, pallida, 0·2 cm. longa; pappus subnullus vel costulis in denticulos brevissimos productis.

HAB.: Cape Colony: South-western Region; rocky mountain-side on the Zwartberg Pass, distr. Prince Albert, alt. about 4,700 ft., Dec. (1904) *H. Bolus*, 11551.

Distinct by its peculiar, very small, appressed, ovate, thick leaves. In other respects it may be near the little-known *Ph. junceum* Less. (*Osteospermum junceum* Thunb.), which does not seem to have been collected since Thunberg's time, and (according to Harvey) is now only represented in his herbarium by a very poor deflorate specimen. In habit it bears some resemblance to *Ph. aciculare* (*Iocaste acicularis E. Mey.*). The plant was somewhat abundant where found.

OSTEOSPERMUM TRIPINNATUM, Bolus, n. sp. (Compositæ-Calenduleæ).

O. foliis 3-pinnatipartitis; capitulis paucis, fastigiato-corymbosis in pedunculis sublongis paucifoliatis vel subnudis; involucri squamis 2–3-serialibus, lanceolatis; floribus radii 15–20, disci ∞; achæniis tereti-clavatis, verrucosulis.

Herba lignosa vel fruticulus erectus ramosus, verisimiliter 2½-pedalis vel ultra; caulis validus, striatus, rugosus, pallidus, 0·5 cm. crassus, cum ramis ramulisque pilis rigidis patentibus hirsutus; rami pauci adscendentes foliosi, superiores in corymbis pauciramosis, subfastigiatis, 2–3-pedunculatis, desinentes; folia alterna patentia, sessilia, semiamplexicaulia, circumscriptione lanceolata, 2–3-pinnati-partita, 3–5, usque ad 7·5 cm. longa, ad 3 cm. lata, rhachi hirsuta, segmentis parce pubescentibus forte viscidulisque, pinnis irregulariter dispositis, ima basi simplicibus brevissimis, superioribus pinnulatis, ad 1·5 cm. longis, pinnulis nunc linearibus simplicibus, nunc, in foliis majoribus, incisis, lobulis ultimis semper linearibus acutis; pedunculi monocephali, 5–9 cm. longi, bracteis 1–2, minimis, foliiformibus; capitula subhemisphærica 0·8 cm. longa, 1 cm. diam., involucri squamæ 25–30, erectæ pleræque 2–, rarius sub 3-seriales, lanceolatæ, acutæ, rigidæ, externe scabrido-puberulæ, pallidæ, 0·5–0·6 cm. longæ; flores radii circa 18, ligulis angustis, 0·8–0·9 cm. longis; flores disci ∞; achænia clavata obsolete triquetra, transverse verrucosulo-rugosa, brunnea, 0·4–0·43 cm. longa.

Hab.: Griqualand West, Kalahari Region, "near the Kloof Village in the Asbestos Mountains, September 25, 1811," *Burchell*, 1670 (according to *N. E. Brown*, Kew); near Griquatown (within forty miles of the first-named station), sent by *Mrs. Orpen* in 1873, No. 8303 in my herb.

This is very distinct from any species known to me. In its much cut leaves it approaches to *O. tanacetifolium MacOwan*, but in other respects not only the leaves but the habit and inflorescence are very different.

ERICA MILANJIANA, Bolus, n. sp. (§ Ceramia).

E. foliis 4-nis; floribus terminalibus, 4-nis; corolla cyathiformi, segmentis erectis; filamentis linearibus latitudine æqualibus; antheris exsertis, muticis; ovariis sericeo-lanatis.

Rami diffusi, gracillimi, glanduloso-hirti, cum pedicellis ferruginei, 20–25 cm. longi; folia subdensa, patentia, 4-na, elliptico-oblonga, utrinque angustata, acuta, plana, marginibus reflexis, minute hispidula, distanter glanduloso-ciliolata, subtus pallidiora, 0·4 cm. longa; flores terminales, 4-ni; pedicelli gracillimi, patentes, flexuosi, glanduloso-hirti, 0·6–0·7 cm. longi; bracteolæ subapproximatæ, lineares, minutæ; sepala subulata, acuta vel acuminata, ciliolata, colorata, 0·1 cm. longa; corolla cyathiformis, vix vel non apice contracta, glabra, rosea, 0·25 cm. longa, limbi segmentis erectis, late rotundatis longitudine tertiam partem tubi æquantibus; filamenta linearia, e basi sursum æqualia; antheræ exsertæ, laterales, oblongæ, obtusæ, muticæ, 0·09 cm. longæ, poro duplo longiores; stylus longe exsertus, validus, sursum gradatim angustatus; stigma capitellatum; ovarium sericeo-lanatum.

Hab.: British Central Africa, Milanji Plateau, coll. *T. McClounie* (in herb Kew).

Most nearly allied to *E. tenuipes, Guth.* and *Bol.*, of the South-Western Cape Flora, differing by its 4-nate leaves, more strictly cyathiform corolla (*i.e.*, its erect, not subrecurved, segments), broader filaments, more exserted anthers. It is also near to *E. planifolia*, Linn., and to *E. thymifolia*, Wendl., differing from the former by its exserted anthers, from the latter by the shape of its corolla, its filaments of equal width, muticous anthers, and from both by its 4-nate leaves.

GNIDIA PULVINATA, Bolus, n. sp. (Thymelæaceæ).

G. floribus terminalibus, subglomeratis, exinvolucratis; calycis segmentis reflexis, ovatis lanceolatisve, acutis; petalis e pulvinulis 4, *processibus erectis filiformibus cum pilis intermixtis præditis, pulvillum annularem ostium tubi fere claudentem efformantibus; antheris superioribus cassis minimis, inferioribus perfectis multo majoribus.*

Fruticulus 3–4-pedalis; rami diffusi, rigidi; pubescentes, cito glabrescentes, cinerei, cicatricoso-tuberculati; folia conferta, opposita vel subsparsa, juniora suberecta imbricata, vetustiora incurvo-patentia, anguste lanceolata, longe attenuata, obtuse acuta, coriacea, haud pungentia, transverse rugulosa, minute tuberculosa, juniora dense pilosa, demum glabrescentia, 1–1·4 cm. longa, 0·2 cm. lata; flores terminales, in glomerulis 3–5-floris, exinvolucrati, sessiles; calycis tubus subgracilis fauce ampliatus, tomento denso subintertexto vestitus, 1–1·2 cm. longus, 0·1–0·12 cm. diametro, segmentis reflexis, e basi lata ovatis lanceolatisve, acutis, utrinque tomentosis supra demum glabrescentibus, sordide purpureis, 0·6 cm. longis, 0·25 cm. latis; petala e pulvinulis 4-prominulis, crassis, carnosis, glabris, nitidis, in fauce tubi sitis orta, multipartita, segmentis erectis filiformibus brevibus, numerosissimis exterioribus gradatim minoribus, pilis albis sericeis longioribus intermixtis, totus pulvillum annularem densum efformans; antheræ inferiores perfectæ multo majores, superioribus cassis.

HAB.: Cape Colony; Bredasdorp Division, on the mountains between Caledon and Elim, alt. about 600 ft., Oct., *Bolus*, 9238! near Koude River, 1,000 ft., Dec., *Schlechter*, 9619!

In habit and general appearance near to *G. scabrida*, Meisn., and *G. pubescens*, Berg., but differing from both in floral characters.

STRUTHIOLA LEPTANTHA, Bolus, n. sp. (Thymelæaceæ).

S. foliis oppositis; floribus axillaribus; calycis segmentis oblongis acutis; petalis bipartitis segmentis erectis subulatis subobtusis

carnosis, pilis copiosis æquilongis circumdatis; antheris in summa fauce tubi sitis inclusis acutis.

Fruticulus erectus ramosus, 2–3-pedalis; rami erecti patentesve, rigidi, puberuli, glabrescentes, cinerei, interdum cicatricibus foliorum delapsorum prominulis notati; folia opposita, patentia, vel erecta imbricataque, linearia vel anguste oblanceolata, subacuta, coriacea, rigida, glabra, ciliata vel rarius subnuda, supra concava, subtus trinervia, 0·7–1 cm. longa; flores axillares, erecto-patentes, in ramulis superioribus laxe dispositi; calycis tubus gracilis, rectus vel decurvus, ampliatus, pilis albis sericeis appressis pubescens, sæpius 1·5–2·1 cm. longus, vel rarius in exemplaribus nonnullis, depauperatis, 0·5–1 cm. longus, 0·04–0·05 cm. diametro, segmentis patentibus, demum sæpius reflexis, oblongis acutis vel subulatis acuminatis, sæpe subinæqualibus, 0·25–0·35 cm. longis; petala bipartita, segmentis erectis, subulatis, subobtusis, carnosis, circa 0·15 cm. longis, pilis basalibus copiosis sericeis albis æquilongis circumdatis; antheræ in fauce summa tubi sitæ, inclusæ, subulatæ, acutæ; stylus tubo calycis dimidio brevior.

Hab.: Cape Colony; Namaqualand Minor, near Ookiep, 3,200 ft., Sept., *Bolus* (No. 688 of Herb. Norm. Aust.-Afr.); Clanwilliam, Blaauwberg, Aug., *Schlechter*, 8488! Pikenier's Kloof, 850 ft., *id.*, 4938! Calvinia Division, near Nieuwoudtville, *C. L. Leipoldt!* Malmesbury Division; Groene Kloof, 300 ft., Oct., *Bolus*, 4322!

Eulophia Flanaganii, Bolus, n. sp. (Orchidaceæ-Vandeæ).

E. foliis syanthiis angustis, petalis super labellum deflexis, labelli lobo intermedio truncato retusove, calcare ovato brevi, pollinium stipitibus glandulisque (an semper?) discretis, ovario apodo.

Herba gracilis erecta, glabra, 1¼–1½-pedalis; folia circa 4, synanthia, rigida, lineari-ensiformia, acuminata, multinerva, 25–35 cm. longa, 0·3–0·7 cm. (saepius 0·3–0·4 cm.) lata; scapus rectus subflexuosusve, striatus, 0·2–0·25 cm. diametro, foliis longior, vaginis 4 appressis acutis vel acuminatis multinervis, stramineis vestitus, inferioribus 5 cm. longis, superioribus sensim brevioribus; racemus sublaxus, subsecundus, 12–20-fl., bracteis ovatis acuminatis, inferioribus 1 cm. longis, superioribus sensim brevioribus; sepala patentia æqualia, oblonga breviter acuta, glauco-virescentia, 0·9 cm. longa, 0·25 cm. lata; petala super labellum deflexa, oblonga, apiculata, lilacina, sepalis æquilonga, 0·4 cm. lata; labellum porrectum, cuneatum, 3-lobum, lilacinum, sepalis æquilongum, lobis lateralibus abbreviatis intermedio multo majore quadrato subtruncato vel leviter retuso, apice 0·5 cm. lato, infra apicem papillis setiformibus, acumi-

natis, hyalinis, in fasciculo quadrato confertis, basin versus papillis brevioribus in seriebus tribus dispositis, ornatum; calcare ovato, 0·2 cm. longo; columna sessilis, oblonga, subtetragona, nec in pedem basi producta; pollinia in stipitibus oblongis discretis inter se paullo distantibus per filum extensivum affixa, glandulis ovatis (an semper?) discretis.

HAB.: Cape Colony, Komgha Division, on grassy slopes near the mouth of the Kei River, alt. 200 ft., fl. Jan., *Flanagan*, 1029 (in herb. Kew, Bolus, &c.); mountain slopes near Queenstown, alt. 4,000 ft., fl. Jan., *Galpin*, 1713! Eland's Hoek, near Aliwal North, alt. 4,500 ft., *F. Bolus* (No. 10544 in my herb.).

Described from living specimens of Flanagan's No. 1029. The colour of the sepals is cold pale green, somewhat livid, faintly mottled, the petals and lip pale lilac with purple edges near the apex. The separation of the stipites and glands of the pollinia may be a sport. I have not observed it before in any other species, but found it identical in two flowers of Flanagan's 1029, dissected. The species resembles *E. laxiflora*, Schltr., but is distinguishable by the absence of any chin or projecting foot at the base of the column, as well as by colour differences. In some of the *Eulophiæ* the colours of the flower vary considerably, especially in the lip, and too much reliance must not be placed upon them; in others, especially the unicoloured species, there seems to be little variation.

MYSTACIDIUM, Lindl.

(Note on the S. African species of this genus.)

In my *Icones Orchidearum Austro-Africanarum*, under t. 7 (*Angræcum Gerrardii mihi*), I endeavoured to show that the genus Mystacidium should be restricted to those plants having the peculiar bearded appendages to the rostellum, which were described by Lindley in establishing the genus (*Comp. to Bot. Mag.*, v. 2, 206). These appendages being often of small size, and attached to an organ which generally loses its shape in dried specimens, have possibly been overlooked by European botanists, or, if seen, have not been regarded as of generic importance. In respect to this genus and Angræcum (as well as to other allied genera), great differences of opinion have existed among orchidologists, and much inconvenience has resulted therefrom. In the desire to refrain as far as possible from adding to this, I have reconsidered the course adopted in the work first above cited, and have concluded that it would be better to change it. The chief characters adopted by Pfitzer (in *Natürliche Pflanzenfamilien*, II. 6. 214, 216), and by Rolfe (in the *Flora of*

Tropical Africa, vol. 7, 133, 169), as distinguishing Mystacidium from Angræcum, are, that the former has flowers with the two pollinia on two distinct stipes, each with a separate gland; while the latter has two pollinia on a single stipe and gland. These characters have the merit of clearness; and I have no sufficient reason to doubt their constancy, though I am under the impression that I have seen flowers of *M. filicorne* with a single, or two very closely approximate, glands. I propose now to follow these authorities, and the more willingly since this arrangement will probably be adopted in the continuation of the *Flora Capensis.* The result is simply to enlarge the limits of Lindley's Mystacidium; while the peculiar character which he had in view might with advantage be used as forming the section Eumystacidium. The South African species at present known would then be arranged thus:—

1. MYSTACIDIUM filicorne, Lindley, in Comp. to Bot. Mag., 2,206; Thesaur. Cap. 2, t. 175; Bolus, Icon. Orch. Aust.-Afr., t. 55. (*Epidendrum capense*, Berg, Descr. Pl. Cap. (1767), 347; Linn. f., Suppl. (1781), 407. *Limodorum longicorne*, Thunb., Prodr. (1794), 3; Swartz, in Schrader's Journ., Bot. (1799), 230. *Eulophia longicornis*, Spreng., Syst. Veg. (1826), 3,720. *Angræcum capense*, Lindl., Gen. Sp. Orch. (1833), 248. *Aeranthus filicornis*, Reichb. fil., in Walp. Ann. (1861), 6,900.)

2. M. gracile, Harvey, Thes. Cap. (1863), 2, t. 174; Bolus, Icon. Orch. Aust.-Afr., t. 56.

3. M. pusillum, Harvey, Thes. Cap. (1863), 2, t. 173; Bolus, l.c., t. 57.

4. M. Gerrardii, Bolus, in Journ. Linn. Soc., vol. 25 (1889), 187. *Aeranthus Gerrardii*, Reichb. f., in "Flora' (1867), p. 117. *Angræcum Gerrardii*, Bolus, Icon. Orch. Aust.-Afr., v. 1 (1893), t. 7.

5. M. Pegleræ, Bolus (see below).

6. M. Caffrum, Bolus (*Angræcum caffrum*, Bolus, Icon. Orch. Aust.-Afr., t. 8).

7. M. Millari, Bolus (see below).

8. M. Flanaganii, Bolus (*Angræcum Flanaganii*, Bolus, Icon. Orch. Aust.-Afr., t. 52).

Rostellum with two bearded appendages (§ Eumystacidium Pfitzer, amended)	
Sepals and petals nearly equal and all acute or acuminate.	
Spur of the lip 3·5–5·2 cm. long; leaves 3–9 cm. long ..	*filicorne*, Lindl.
,, ,, ,, 3–3·5 cm. long; leaves 2–3·8 cm. long ..	*gracile*, Harv.
Petals obtuse, shorter than the sepals	*pusillum*, Harv.
Rostellum naked (§ Gomphocentrum, *Pfitzer*).	
Lip about as broad near the apex as its length.	
Lip trowel-shaped, spur falcately incurved	*Gerrardii*, Bolus.
Lip fan-shaped, spur slightly incurved..	*Pegleræ*, Bolus.

Lip ovate, obtuse, in length about 1½ times its breadth.	
Spur about as long as the ovary	*Caffrum*, Bolus.
Spur about twice as long as the ovary	*Millari*, Bolus.
Lip ovate-lanceolate, acute, length about 2½ times its breadth	*Flanaganii*, Bolus.

MYSTACIDIUM PEGLERÆ, Bolus, n. sp. (Orchidaceæ-Vandeæ).

M. (§ Gomphocentrum) *sepalis lateralibus lanceolatis, impari oblongo obtuso, inter se subæquilongis; petalis rhomboideis; labello arcuato-deplexo subflabelliformi, obscure trilobulato, sepalis dimidio longiore, calcare cylindrico quam lamina paullo longiore.*

Epiphyta glabra; radices aerales filiformes, 0·15 cm. crassæ; caulis validus foliatus, vaginis nervosis foliorum delapsorum vestitus, 5–6 cm. longus; folia disticha, erecto-patentia, ligulata, inæqualiter biloba, lobulis obtusis, basi angustata, semiamplexicaulia, coriacea, 3–5 cm. longa, 0·7–1 cm. lata; racemi squarroso-patentes; rhachis fractiflexa, 5–6-flora, 4–5 cm. longa; flores erecti, albi; sepala lateralia, patentia, oblanceolata, acuta, 0·25 cm. longa; sepalum impar erectum oblongum ovatumve, obtusum, quam lateralia paullo brevius; petala erecto-patentia, rhomboidea, angulis rotundatis, 0·18 cm. longa, 0·17 cm. lata; labellum arcuato-deflexum, subflabelliforme, angulis rotundatis, margine antico obscure 3-lobo, lateralibus subundulatis, tota lamina manu explanata 0·35–0·4 cm. longa, basi in calcar dependens subincurvum cylindricum, 0·5 cm. longum, 0·075 cm. crassum productum; columna decurva, oblonga, emarginata; rostellum deflexum, lanceolatum, acutum; pollinia globosa in stipitibus capillaceis affixa, glandulis ovatis minimis.

HAB.: Cape Colony, South-eastern Region, district Kentani, in a forest near Kentani, on trees, alt. 1,000–1,200 ft., Feb., *Miss A. Pegler*, No. 993!

Described from dried specimens and fresh flowers preserved in formalin. In general appearance this most nearly resembles *M. caffrum mihi* (see note above), but is well distinguished by its smaller flowers, different sepals and petals, and more especially the lip. I am indebted for this and many other good things to Miss Pegler, who has made excellent collections in the neighbourhood of Kentani, a district hitherto very little explored. To her we owe the detection of *Dermatobotrys Saundersii mihi* (hitherto only known from Natal) within this Colony, and the rediscovery of *Stangeria Katzeri, Regel,* the native station of which was previously unknown.

MYSTACIDIUM MILLARI, Bolus, n. sp. (Orchidaceæ-Vandeæ).

M. (§ Gomphocentrum) *sepalo impari oblongo obtusissime rotundato, concavo, basi dente in utroque margine aucto ; petalis ovatis ; labelli lamina ovata, obtusa, calcare basi inflato deinde cylindrico, sensim attenuato, quam lamina 3½-plo longiore.*

Epiphyta caulescens glabra; radices aerales 0·23 cm. crassæ; caulis validus, 0·4–0·5 cm. crassus, vaginis foliorum delapsorum vestitus; folia 2–3, pleraque apicè caulis conferta, erecto-patentia, ligulata subundulata, inæqualiter biloba, lobis angustatis subobtusis, medio nervo depresso percursa, coriacea, 8·5 cm. longa, 1·4–1·6 cm. lata; racemi squarrosi subrecti rigidi, 7–10-flori, 2–4 cm. longi; flores plerique erecti, albi; pedicelli cum ovario 0·8–0·9 cm. longi; sepala lateralia patentia, oblongo-oblanceolata, subacuta, 0·6 cm. longa, parte latiore 0·22 cm. lata; sepalum impar erectum, oblongum, obtusissimum, subconcavum, basi dente in utroque margine auctum, 0·6 cm. longum, 0·45 cm. latum; petala erecto-palentia, oblique ovata subacuta, sepalis paullo breviora, 0·32 cm. lata; labelli lamina ovata, obtusa, concava, apice decurva, petalis æquilonga, calcare basi inflata, deinde cylindrico incurvo, 2 cm. longo; columna decurva, oblonga vel subrhomboidea, infra medium dilatata; pollinia lenticularia, in stipitibus filiformibus, glandulis ovatis; rostellum exappendiculatum.

HAB.: Natal, near Durban, on trees, alt. 500 ft., fl. Jan., Coll. A. D. Millar (Natal Gov. Herb., No. 8437).

Described from fresh specimens; flowers white. In the general appearance of the flowers this resembles *M. gracile Harv.;* but the shape of the perianth segments and the nude rostellum, show it to be quite distinct. I can find nothing like it amongst the tropical Mystacidia in the *Flora of Tropical Africa.*

HOLOTHRIX CULVERI, Bolus, n. sp. (Orchidaceæ-Ophrydeæ).

H. (§ *Tryphia*) *spica dense multiflora ; sepalis lanceolatis acutis, in var. β lateralibus basi calcaratis ; petalis oblongis acutis, quam sepala dimidio longioribus, duplo latioribus ; labello subquadrato, 3-lobulato, vel, in var. β, lobulis lateralibus carentibus.*

Folia radicalia 2 (?), unicum tantum visum emarcidum ovatum; scapus erectus gracilis, vaginulis remotis erectis lanceolatis acuminatis aristulatis membranaceis vestitus, basin versus retrorse pilosus sursum glabrescens, ad 12 cm. altus; spica cylindrica, dense multiflora (30–60-fl.), 4–5 cm. longa, 0·8 cm. diam., floribus quaquaversis (vel interdum, ex collectore, secundis); bracteæ lanceolatæ acuminatæ, inferiores ovario paullo longiores, superiores breviores; sepala lateralia oblanceolata, dorsale oblongum, 0·22 cm. longa; petala patenti-reflexa, oblonga, acuta, 0·31 cm. longa, quam sepala duplo latiora, cum labello minute papilloso-scabriuscula; labellum subquadratum, 3-lobum, lobulis lateralibus patentibus dentiformibus, vel in var. β omnino carentibus, lobo intermedio multo majore, subtrulliformi, breviter acuto, supra basin angustato, marginibus eleganter curvo-ampliatis, tota lamina 0·35 cm. longa et lata, basi in calcar subrectum acutum, 0·15–0·2 cm. longum, producta; columna ovalis; pollinium caudiculæ brevissimæ, glandulis discretis vel (ex collectore), filo extensivo connexis.

Var. β, *integra;* sepalis lateralibus calcaratis; labelli lobulis lateralibus carentibus; ceteris ut in typo.

Hab.: Transvaal Colony; Fig-tree Creek, near Barberton, on rocky slopes, alt. about 2,000 ft., Sept. (1890), *W. Culver*, 84! Var. β growing with and close to the typical form, *Culver*, 84a! (in herb. Schlechter; Bolus).

Petals and lip white. Most nearly allied, amongst the South African species known to me, to *H. MacOwaniana*, Reichb. f.; but the aspect is different, the spike being much closer and more numerously flowered. I believe this is the only known instance of spurred sepals in the genus.

Disa Marlothii, Bolus, n. sp. (Orchidaceæ-Diseæ).

D. (§ Eu-Disa), *foliis synanthiis radicalibus expansis herbaceis; racemis paucifloris, laxis; floribus mediocribus; calcare sepali imparis patente subelongato; petalis obtusis; rostello apice integro.*

Herba erecta, glabra, 14–25 cm. alta; folia synanthia, radicalia, plura, oblanceolata, acuta, herbacea, basi longe membranaceo-vaginantia, 3–5 cm. longa, parte latiore 0·8–1·1 cm. lata; caulis gracilis, substrictus, vaginis 4–7, erectis, herbaceis, marginibus submembranaceis, arcte amplectentibus vestitus; racemus saepius laxissime 2–5-florus, vel in exemplaribus macilentis 1-florus, pedicellis gracilibus elongatis; bracteæ vaginis conformes sæpe marginibus coloratis, ovario multo breviores; flores patentes, in sectione mediocres, saturate rosei, galea petalisque maculis purpureis notatis; sepala lateralia patentia late oblonga, obtusissima, sub apice mucronulata, 0·9–1 cm. longa; sepalum impar posticum, galeatum, oris ambitu obovato obtuse acutiusculo, sepalis lateralibus æquilongum dorso in calcar patens vel subadscendens nullo modo deflexum substrictum vel levitur recurvum, apice valde attenuatum, 1·4–1·9 cm. longum, productum; petala erecta sub galea semiabscondita, late oblonga, obtusissima, basi postice angulo recto abrupte geniculato-

inflexa, rostello subduplo longiora; labellum porrectum, spathulato-oblongum, subacutum, circa 0·9 cm. longum; anthera valde resupinata, subreflexave, ovario parallela; rostellum erectum, oblongum, apice inter glandulas angustatum; ovarium gracile, cylindricum, cum pedicello, ad 2 cm. longum.

Hab.: Cape Colony; district Worcester, in swamps, Sand-drifts Kloof, Hex River Mountains, altitude about 3,200 ft., Jan. 4, 1897, *Dr. Marloth*, 2378! Same place *A. Bolus* (No. 6371 of my herb.). District Ceres; on the Skurfdebergen, near Klein Vley, altitude about 6,000 ft., Jan., *R. Schlechter*, 10,204!

A very distinct species, in floral structure nearest to *D. pulchra*, Sond., of which, though dissimilar in appearance, it might be regarded as a miniature Western representative. The petals in this, however, are very different, and the rostellum is proportionately much higher. In its inflorescence and the general shape of the flowers it is strikingly like *D. gladioliflora*, Burch. (which Schlechter has placed in the § *Oregura*), but is at once distinguishable from that by its herbaceous expanded leaves and the high suberect rostellum. It has also some relation with the very different-looking *D. caffra*, mihi, and I should place it between that and *D. pulchra*.

DISA SCHLECHTERIANA, Bolus, n. sp. (Orchidaceæ-Diseæ).

D. (§ Microperistera, *Bolus, nov. sect.*) *foliis rigidis, gramineis, hysteranthiis vel cum ortu scapi marcescentibus, floribus inter majores, sepalo impari subgaleato, longissime calcarato, petalis minimis, resupinatis uncinatis, labello oblongo-lanceolato.*

Herba erecta, glaberrima, ad 5·5 decim. alta; folia radicalia, 7–11, erecta, linearia, acuminata, rigida, prominenter nervata, 30 cm. longa, 0·1–0·13 cm. lata; scapus substrictus, vaginis membranaceis acuminatis arcte amplectentibus, marginibus basi longe connatis, distanter vestitus; bracteæ patentes, membranaceæ, ovatæ, acuminatæ, venosæ, ovario breviores; racemus laxe 6–12-florus, 8–14 cm. longus, flores inter majores hujus sectionis, patentibus, cremeis, colore et indole eos *D. Draconis Swtz.* in mentem revocantibus; sepala lateralia patentia, oblonga, acuta, 2·3 cm. longa; sepalum impar erectum subgaleatum ovatum acuminatum, apice recurvatum, ore ovato acuto 2·3 cm. longo, 1·5 cm. lato, basi sensim in calcar filiforme eleganter decurvum, ad 4·8 cm. longum, ovarium excedens, productum; petala minima resupinata, e basi lata orbiculari deinde angustata, abrupte incurvo-uncinata, acuminata, altitudine rostellum vix superantia; labellum patulum oblongo-lanceolatum acutum integrum, supra basin leviter constrictum,

1·8–2 cm. longum; anthera resupinata; pollinium glandulæ discretæ; rostellum erectum, subelongatum, leviter incurvum, oblongum, apice tridentatum; stigma pulviniforme; capsula erecta, clavato-cylindrica, ad 3·8 cm. longa.

Hab.: Cape Colony, Riversdale Division, in Garcia's Pass (Langebergen), on rocky mountain sides, alt. about 1,800 ft., fl. December (1904), collected and sent by Mrs. C. Luyt; No. 10571 in my herb. (also in herb. Kew, &c.).

This much resembles *D. Draconis*, Swtz., but cannot, in my opinion, be fitly placed in any existing section. From the § Coryphæa it differs by its rigid, wiry, grass-like leaves, the small, subresupinate, uncinate petals, and the rather high rostellum. In all these characters it approaches the § Herschelia. From the latter, however, it is separated by the structure of the flowers generally, by the very entire lip, by the two distinct glands of the pollinia and the corresponding modification of the rostellum. There is nothing in the structure of the flower to suggest hybridity.

PTERYGODIUM LEUCANTHUM, Bolus, n. sp. (Orchidacæa-Disperideæ).

Pt. (§ Eu-Pterygodium, *Schltr.*) *sepalo impari oblongo obtusissimo, basi angustato; labello pendulo transverse oblongo abbreviato obtusissimo vix emarginato, appendice quam labellum multo longiore, erecta, oblonga, carnosa, sursum angustata, apice breviter bifida, lobis deflexis, uncinatoincurvis, incrassatis, carnosis, discoloribus.*

Herba glabra, erecta, 15–35 cm. alta; caulis gracilis, subflexuosus, foliatus; folia 4–5, erecto-patentia, ovato-lanceolata, acuta, siccitate membranacea venosaque, ad 8 cm. longa; racemus laxe 7–10-fl., bracteis erectis lanceolatis acuminatis floribus subæquilongis; sepala lateralia patentia cymbiformia acuta, margine anteriori obscure unidentata, circa 0·8 cm. longa; sepalum impar erectum oblongum obtusissimum, basi angustatum cum petalis adhærentibus concavis cucullum suborbiculare efformantibus, sepalis lateralibus æquilongum; petala semiorbicularia, basi modice gibbosa; labellum abbreviatum, oblongum, latius quam longum, bilobulatum emarginatumve, lobulis rotundatis, sursum in appendicem erectam, oblongam, carnosam, apicem versus sensim angustatam, bifidam, productum, lobulis deflexis, uncinato-incurvis, incrassatis, subdivaricatis, obtusis discoloribus. (Ex. exempll. plur viv.)

Hab.: Cape Colony; South-eastern Region, district Engcobo, in steep rocky places on the Engcobo Mountain, alt. about 4,400 ft., fl. Jan., *H. G. Flanagan! Bolus* 8704! also in district Maclear, on the slopes of the Kwenkwe Mountain, near the Gatsberg,

alt. 5,500 ft., Jan., *Bolus!* Orange River Colony; on the Mapede's Peak, alt. 8,100–8,400 ft., Feb., *Thode, 57b!*

Colour of sepals pale green, petals white, lip white with faint green stripes, the incurved tips of the appendage very dark green. The specimens dry pale or yellowish, but these tips remain as two dark oval spots and serve at once to distinguish the species in the dried state. In habit and floral structure, especially by the form of the lip and appendage (which latter is about four times longer than the petaloid lip proper), it is allied to *Pt. catholicum*, Swartz, and to *Pt. acutifolium*, Lindl., but is very distinct from either. It appears to be rare, and only a few specimens were obtained by each of the collectors.

PTERYGODIUM DEFLEXUM, Bolus, n. sp. (Orchidaceæ-Disperideæ).

Pt. (§ Corycium, *Schltr.*) *sepalo impari obcuneato-oblongo, obtusissimo; labello cuneato-unguiculato, subreniforme, bilobo, lobis divaricatis, appendice e basi lineari adscendente, apice biloba, lobis abrupte deflexis subulatis acuminatis curvis, floris basin fere attingentibus.*

Herba erecta, glabra, 12–20 cm. alta; scapus validus, subflexuosus, foliatus; folia 4–6, erecto-patentia, e basi lata vaginante membranacea linearia, acuminata, multivenia, 6–10 cm. longa, superiora sensim minora; spica sublaxe 5–20-flora, 4–7 cm. longa, 2·3–2·7 cm. diam., floribus erecto-patentibus; bracteæ ovatæ, acutæ, membranaceæ, venosæ, medio plicato-constrictæ, floribus paulo breviores; sepala lateralia antica in laminam late ovatam deflexo-patentem, 0·75 cm. longam, coalita, lobis obtusis, marginibus leviter inflexis; sepalum impar obcuneato-oblongum, obtusissimum, 0·8 cm. longum, cum petalis adhærentibus saccum efformantibus, ore suborbiculari 0·9 cm. lato, basi bene gibbosum ultra apicem ovarii productum; labellum e basi cuneata unguiculatum, subreniforme, bilobum, 0·5 cm. longum, apice 0·6 cm. latum, lobis divaricato-patentibus obtusis, appendice erecta, carnosa, lineari, apice biloba, lobis subulatis acuminatis, curvis, abrupte deflexis, floris basin fere attingentibus.

HAB.: Cape Colony (South-western Region), open hillsides, Koudeberg, near Wupperthal, district Clanwilliam, alt. about 2,500 ft., fl. Oct. (1897), coll. H. Bolus, No. 8660.

Very distinct by the lip-appendage, the dark green colour of which forms a sort of band inside and close to the yellow petals. The bracts and sepals are smoky-brown. The tubers and roots are hairy. Twenty or thirty specimens were found growing together; and the species was drawn and described from life.

The following rare and little known species having turned up again after a lapse of some seventy years, I have thought it desirable to describe it more fully:—

PTERYGODIUM BIFIDUM (Sond.), Schltr., in Bull. Herb. Boiss. v. 6 (1898), p. 856 (Orchidaceæ-Disperideæ).

(§ Corycium, Schltr.)

Erecta, glabra, semi-pedalis; folia circa sex, erecta, lanceolata, acuminata, basi vaginantia, duo inferiora 4·2 cm. longa, superiora sensim minora; spica cylindrica, dense multiflora, obtusa, 6·5 cm. longa, 1 cm. diam., floribus confertis, regulariter dispositis, subsessilibus; bracteæ ovatæ vel lanceolatæ, acuminatæ, membranacæ, inferioribus flores excedentibus; sepala lateralia antica, in laminam oblongam vel suborbicularem concavam, obtusissimam, retusam vel bifidam marginibus inflexis, coalita, 0·45 cm. longa; sepalum impar lanceolatum acuminatum, 0·45 cm. longum; petala semiorbicularia valde concava, marginibus exterioribus inflexis, cucullum suborbicularem, 0·4 cm. latum, efformantia; labellum pendulum, ligulatum (lanceolatum, ex Sonder) acutum, integerrimum, basi haud angustatum, trinervum, 0·35 cm. longum, 0·093 cm. latum, appendice æquilonga, erecta, unguiculata, ovata, obovatave, carnosa, apicem versus angulo subrecto cucullato-inflexa, costa prominenti longitudinaliter percursa; ovarium ovatum, apice in collum gracile angustatum. *Corycium bifidum*, Sond., *in Linnæa, v.* 19, *p.* 111. *C. ligulatum*, Reichb. f., *ibid.* p. 375; *Walp. Annales, v.* 1, *p.* 805; *Bolus, Orch. Cape Penins, p.* 180.

HAB.: Mountains near Cape Town, *Ecklon & Zeyher* (ex Sond.); near Caledon, sent by Mr. A. W. Goatcher, Jan., 1904, No. 10568 in my herb.

This species has a somewhat similar floral structure to that of *Pt. microglossum*, Schltr., but is utterly different in general appearance and size and in the shape of the lip. In habit it resembles *Pt. bicolorum*, Schltr., and *Pt. excisum*, Schltr.; but also differs in the lip and in the smaller size of its flowers, which are, indeed, the smallest in the genus, about 25–30 being contained in a length of an inch on the spike. The species is rare; it has not been found since Ecklon and Zeyher's time until now, and was previously unseen both by Schlechter and myself. Of the identity with the type there is scarcely a doubt.

NOTES ON SEMICIRCULANTS.

By Thomas Muir, LL.D.

(Read May 31, 1905.)

1. Some attention has been given to the eight-line determinant

$$\begin{vmatrix} a & b & c & d & e & f & g & h \\ h & a & b & c & d & e & f & g \\ g & h & a & b & c & d & e & f \\ f & g & h & a & b & c & d & e \\ h & g & f & e & d & c & b & a \\ a & h & g & f & e & d & c & b \\ b & a & h & g & f & e & d & c \\ c & b & a & h & g & f & e & d \end{vmatrix}$$

but apparently with no satisfactory result. The evaluation of it was set as a problem in the *Educational Times* for April, 1904, and a supposed solution was given in the number for September of the same year,* the result being that the value was found to be the same as that of the ordinary circulant $C(a, b, c, d, e, f, g, h)$. But although the first four rows of the given determinant are the same as those of the said circulant, the last four rows are really the first four rows of the reverse circulant $C(h, g, f, e, d, c, b, a)$. The matter thus seems to call for more careful investigation.

2. Let us first make a fresh examination of the ordinary circulant. Performing on it the operations

$$\begin{gathered} \text{col}_1 + \text{col}_3 + \text{col}_5 + \text{col}_7, \\ \text{col}_2 + \text{col}_4 + \text{col}_6 + \text{col}_8, \end{gathered}$$

we find it equal to

$$\begin{vmatrix} \omega & \epsilon & c & d & e & f & g & h \\ \epsilon & \omega & b & c & d & e & f & g \\ \omega & \epsilon & a & b & c & d & e & f \\ \epsilon & \omega & h & a & b & c & d & e \\ \omega & \epsilon & g & h & a & b & c & d \\ \epsilon & \omega & f & g & h & a & b & c \\ \omega & \epsilon & e & f & g & h & a & b \\ \epsilon & \omega & d & e & f & g & h & a \end{vmatrix}$$

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* See also *Math. from Educ. Times*, (2) vii., p. 55.

where ω denotes the sum of the odd-placed elements, and ϵ the sum of the others. If on this the second set of operations

$$\text{row}_8-\text{row}_6,\quad \text{row}_7-\text{row}_5,\quad \text{row}_6-\text{row}_4,\quad \ldots\ldots$$

be performed, we have

$$\begin{vmatrix} \omega & \epsilon & c & d & e & f & g & h \\ \epsilon & \omega & b & c & d & e & f & g \\ \cdot & \cdot & a-c & b-d & c-e & d-f & e-g & f-h \\ \cdot & \cdot & h-b & a-c & b-d & c-e & d-f & e-g \\ \cdot & \cdot & g-a & h-b & a-c & b-d & c-e & d-f \\ \cdot & \cdot & f-h & g-a & h-b & a-c & b-d & c-e \\ \cdot & \cdot & e-g & f-h & g-a & h-b & a-c & b-d \\ \cdot & \cdot & d-f & e-g & f-h & g-a & h-b & a-c \end{vmatrix}$$

or

$$(\omega+\epsilon)\,(\omega-\epsilon)\,\Delta_6,$$

where Δ_6 is a function of the eight differences

$$a-c,\ b-d,\ c-e,\ d-f,\ e-g,\ f-h,\ g-a,\ h-b,$$

being in fact, save as to sign, the persymmetric determinant

$$\text{P}\left(\begin{matrix} & e-g & & g-a & & a-c & & c-e & & e-g & \\ d-f & & f-h & & h-b & & b-d & & d-f & & f-h \end{matrix}\right). \qquad \text{(I.)}$$

A similar result is of course obtainable in reference to all circulants of even order.

3. Taking now the given semicirculant, if we may so term it, and proceeding in almost quite the same manner, we find it equal to

$$\begin{vmatrix} \omega & \epsilon & c & d & e & f & g & h \\ \epsilon & \omega & b & c & d & e & f & g \\ \cdot & \cdot & a-c & b-d & c-e & d-f & c-g & b-h \\ \cdot & \cdot & h-b & a-c & b-d & c-e & b-f & a-g \\ \cdot & \cdot & f-h & e-a & d-b & \cdot & \cdot & \cdot \\ \cdot & \cdot & g-a & f-b & e-c & \cdot & \cdot & \cdot \\ \cdot & \cdot & h-b & g-c & f-d & \cdot & \cdot & \cdot \\ \cdot & \cdot & a-c & h-d & g-e & \cdot & \cdot & \cdot \end{vmatrix},$$

and therefore equal to 0, since the co-factor of $\omega^2-\epsilon^2$ here vanishes.

Of course the same final result might be reached without removing the factor $\omega^2-\epsilon^2$. Further, by performing in succession the operations

$$\begin{gathered}\text{row}_8-\text{row}_1,\quad \text{row}_7-\text{row}_2,\quad \text{row}_6-\text{row}_3,\quad \ldots\ldots \\ \text{col}_7+\text{col}_5,\quad \text{col}_8+\text{col}_4,\quad \text{col}_1+\text{col}_3,\quad \ldots\ldots\end{gathered}$$

we can make it appear that

$$\begin{vmatrix} g-a & f-b & e-c \\ h-b & g-c & f-d \\ a-c & h-d & g-e \end{vmatrix}$$

also is a factor, and that the vanishing co-factor of the 5th order may have $\omega+\epsilon$, $\omega-\epsilon$ removed from it, leaving only

$$\begin{vmatrix} g-a & f-b & e-c \\ h-b & g-c & f-d \\ g-a & f-b & e-c \end{vmatrix}$$

which differs from the previous three-line factor in having its third row identical with its first.

By any of the methods here indicated it is easy to establish the general theorem: *Every semicirculant of order 4m vanishes.* (II.)

4. In the case of the other even orders, say the order $4m+2$, the result is different. As before we readily see that $\omega+\epsilon$ and $\omega-\epsilon$ are factors: their co-factor, however, does not now vanish. Thus taking the six-line determinant

$$\begin{vmatrix} a & b & c & d & e & f \\ f & a & b & c & d & e \\ e & f & a & b & c & d \\ f & e & d & c & b & a \\ a & f & e & d & c & b \\ b & a & f & e & d & c \end{vmatrix}$$

and performing the operations

$$\mathrm{col}_1 + \mathrm{col}_3 + \mathrm{col}_5, \quad \mathrm{col}_6 + \mathrm{col}_4 + \mathrm{col}_2,$$
$$\mathrm{row}_6 - \mathrm{row}_2, \quad \mathrm{row}_5 - \mathrm{row}_3, \quad \mathrm{row}_4 - \mathrm{row}_2, \quad \mathrm{row}_3 - \mathrm{row}_1,$$

we find it

$$= \begin{vmatrix} \omega & b & c & d & e & \epsilon \\ \epsilon & a & b & c & d & \omega \\ . & f-b & a-c & b-d & c-e & . \\ . & e-a & d-b & . & b-d & . \\ . & . & e-a & d-b & . & . \\ . & . & f-b & e-c & . & . \end{vmatrix},$$

$$= \begin{vmatrix} e-a & d-b \\ f-b & e-c \end{vmatrix} \cdot \begin{vmatrix} f-b & c-e \\ e-a & b-d \end{vmatrix} \cdot \begin{vmatrix} \omega & \epsilon \\ \epsilon & \omega \end{vmatrix},$$

$$= (a+b+c+\ldots)(a-b+c-d+\ldots) \begin{vmatrix} e-a & f-b \\ d-b & e-c \end{vmatrix}^2.$$

5. The ten-line and other cases may be similarly dealt with. There is, however, a much more instructive method; for, if the last $m+1$ columns of such a determinant be moved in a body so as to occupy the first $m+1$ places, the determinant will be found to be centrosymmetric, and therefore resolvable into two determinants of the order $2m+1$, from one of which the factor $a+b+c+d+\ldots$ can be removed, and from the other the factor $a-b+c-d+\ldots$, leaving co-factors which are identical. Thus, shifting as stated the last three columns of the semicirculant of the 10th order, and using 1, 2, 3, … for elements, we have it

$$= \begin{vmatrix} 8 & 9 & t & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ 7 & 8 & 9 & t & 1 & 2 & 3 & 4 & 5 & 6 \\ 6 & 7 & 8 & 9 & t & 1 & 2 & 3 & 4 & 5 \\ 5 & 6 & 7 & 8 & 9 & t & 1 & 2 & 3 & 4 \\ 4 & 5 & 6 & 7 & 8 & 9 & t & 1 & 2 & 3 \\ 3 & 2 & 1 & t & 9 & 8 & 7 & 6 & 5 & 4 \\ 4 & 3 & 2 & 1 & t & 9 & 8 & 7 & 6 & 5 \\ 5 & 4 & 3 & 2 & 1 & t & 9 & 8 & 7 & 6 \\ 6 & 5 & 4 & 3 & 2 & 1 & t & 9 & 8 & 7 \\ 7 & 6 & 5 & 4 & 3 & 2 & 1 & t & 9 & 8 \end{vmatrix}$$

$$= \begin{vmatrix} 8+7 & 9+6 & t+5 & 1+4 & 2+3 \\ 7+6 & 8+5 & 9+4 & t+3 & 1+2 \\ 6+5 & 7+4 & 8+3 & 9+2 & t+1 \\ 5+4 & 6+3 & 7+2 & 8+1 & 9+t \\ 4+3 & 5+2 & 6+1 & 7+t & 8+9 \end{vmatrix} \cdot \begin{vmatrix} 8-7 & 9-6 & t-5 & 1-4 & 2-3 \\ 7-6 & 8-5 & 9-4 & t-3 & 1-2 \\ 6-5 & 7-4 & 8-3 & 9-2 & t-1 \\ 5-4 & 6-3 & 7-2 & 8-1 & 9-t \\ 4-3 & 5-2 & 6-1 & 7-t & 8-9 \end{vmatrix}.$$

The first of these factors, when there is performed on it the operations

$$\text{col}_1 + \text{col}_2 + \text{col}_3 + \ldots\ldots$$
$$\text{row}_5 - \text{row}_4, \quad \text{row}_4 - \text{row}_3, \quad \ldots\ldots$$

is seen to be

$$= (1+2+\ldots+t) \cdot \begin{vmatrix} 8+5-9-6 & 9+4-t-5 & t+3-1-4 & 1-3 \\ 7+4-8-5 & 8+3-9-4 & 9+2-t-3 & t-2 \\ 6+3-7-4 & 7+2-8-3 & 8+1-9-2 & 9-1 \\ 5+2-6-3 & 6+1-7-2 & 7+t-8-1 & 8-t \end{vmatrix},$$

$$= (1+2+\ldots+t) \cdot \begin{vmatrix} 8-6 & 9-5 & t-4 & 1-3 \\ 7-5 & 8-4 & 9-3 & t-2 \\ 6-4 & 7-3 & 8-2 & 9-1 \\ 5-3 & 6-2 & 7-1 & 8-t \end{vmatrix};$$

and similarly the second factor is found

$$= (1-2+3-\ldots-t) \begin{vmatrix} 8-6 & 9-5 & t-4 & 1-3 \\ 7-5 & 8-4 & 9-3 & t-2 \\ 6-4 & 7-3 & 8-2 & 9-1 \\ 5-3 & 6-2 & 7-1 & 8-t \end{vmatrix}.$$

As the common four-line factor is the determinant of the difference of the matrices

$$\begin{array}{cccc} 8 & 9 & t & 1 \\ 7 & 8 & 9 & t \\ 6 & 7 & 8 & 9 \\ 5 & 6 & 7 & 8, \end{array} \qquad \begin{array}{cccc} 6 & 5 & 4 & 3 \\ 5 & 4 & 3 & 2 \\ 4 & 3 & 2 & 1 \\ 3 & 2 & 1 & t \end{array}$$

we may say that the semicirculant of the ten elements 1, 2, 3, ..., t is equal to

$$(1+2+3+4+\ldots+t).(1-2+3-4+\ldots-t)$$
$$\cdot\left|\begin{array}{cccc} 8 & 9 & t & 1 \\ 7 & 8 & 9 & t \\ 6 & 7 & 8 & 9 \\ 5 & 6 & 7 & 8 \end{array} - \begin{array}{cccc} 6 & 5 & 4 & 3 \\ 5 & 4 & 3 & 2 \\ 4 & 3 & 2 & 1 \\ 3 & 2 & 1 & t \end{array}\right|^2.$$

6. The matrices whose difference is the matrix of the squared factor in the preceding are both persymmetric in form, and are both obtainable from the first $2m$ rows of the given semicirculant, after it has been made centrosymmetric, by leaving out the $(2m+1)$th and $(4m+2)$th columns, and in the case of the second matrix reversing the order of the columns. Thus in the case of the fourteen-line semicirculant (*i.e.*, where $m=3$), if the first row be

$$1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7,\ a,\ b,\ c,\ d,\ e,\ f,\ g$$

we shift the last four elements to the front, and so alter the row into

$$d,\ e,\ f,\ g,\ 1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7,\ a,\ b,\ c\,;$$

then we leave out the 7th and 14th, obtaining

$$d,\ e,\ f,\ g,\ 1,\ 2 \qquad 4,\ 5,\ 6,\ 7,\ a,\ b,$$

and thus finally are led to the squared factor

$$\left|\begin{array}{cccccc} d & e & f & g & 1 & 2 \\ c & d & e & f & g & 1 \\ b & c & d & e & f & g \\ a & b & c & d & e & f \\ 7 & a & b & c & d & e \\ 6 & 7 & a & b & c & d \end{array} - \begin{array}{cccccc} b & a & 7 & 6 & 5 & 4 \\ a & 7 & 6 & 5 & 4 & 3 \\ 7 & 6 & 5 & 4 & 3 & 2 \\ 6 & 5 & 4 & 3 & 2 & 1 \\ 5 & 4 & 3 & 2 & 1 & g \\ 4 & 3 & 2 & 1 & g & f \end{array}\right|^2.$$

If, therefore, in addition to the usual notation for persymmetric determinants, viz.,

$$\mathrm{P}\,(a,\,b,\,c,\,d,\,e) \quad \text{for} \quad \begin{vmatrix} a & b & c \\ b & c & d \\ c & d & e \end{vmatrix}$$

we introduce

$$\mathrm{P}'(a,\ b,\ c,\ d,\ e) \quad \text{for} \quad \begin{vmatrix} c & d & e \\ b & c & d \\ a & b & c \end{vmatrix},$$

that is to say, for the determinant which is got from the former by changing the order of the rows and which therefore is symmetric with respect to the second diagonal instead of the first, we may enunciate our result as follows: *The semicirculant of the* $(4m+2)$*th order whose elements are* $1,\ 2,\ \ldots,\ 4m+2$ *is equal to* $(-)^{m-1}(\omega+\epsilon)(\omega-\epsilon)\Delta^2$, *where* ω, ϵ *are the sums of the odd-placed and even-placed elements respectively, and where* Δ *is the determinant of the difference between the matrices of the two persymmetric determinants* [*]

$$\begin{array}{ll} \mathrm{P}'(m+3,\ m+4,\ \ldots,\ 4m+2,\ 1,\ 2,\ \ldots,\ m-1), & \\ \mathrm{P}(3m,\ 3m-1,\ \ldots,\ 1,\ 4m+2,\ 4m+1,\ \ldots,\ 3m+4). & \quad \text{(III.)} \end{array}$$

In connection with this it is interesting to note that in every case there are three elements not included in the first persymmetric matrix, viz., m, $m+1$, $m+2$, and likewise three not included in the second, viz., $3m+3$, $3m+2$, $3m+1$: further, that the element which fills the univarial diagonal in the first matrix is $3m+2$, and in the second matrix $m+1$.

7. If instead of having, as in the foregoing semicirculants, both the cyclical changes right-handed, we make one the opposite of the other, the resulting determinant will be found still resolvable into factors. In this case, however, no distinction is necessary between the orders $4m$ and $4m+2$, centrosymmetry being now always attainable by merely reversing the order of the last m of the $2m$ rows. Thus, when $m=3$ we have

$$\begin{vmatrix} a & b & c & d & e & f \\ f & a & b & c & d & e \\ e & f & a & b & c & d \\ f & e & d & c & b & a \\ e & d & c & b & a & f \\ d & c & b & a & f & e \end{vmatrix} = -\begin{vmatrix} a & b & c & d & e & f \\ f & a & b & c & d & e \\ e & f & a & b & c & d \\ d & c & b & a & f & e \\ e & d & c & b & a & f \\ f & e & d & c & b & a \end{vmatrix},$$

$$= -\begin{vmatrix} a+f & b+e & c+d \\ f+e & a+d & b+c \\ e+d & f+c & a+b \end{vmatrix} \cdot \begin{vmatrix} a-f & b-e & c-d \\ f-e & a-d & b-c \\ e-d & f-c & a-b \end{vmatrix},$$

$$= -\ (a+b+c+d+e+f)\ (a-b+c-d+e-f) \cdot \begin{vmatrix} a-e & b-d \\ f-d & a-c \end{vmatrix}^2.$$

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[*] In P to find the variables we run our eye along the first row and down the last column, in P′ up the first column and along the first row. If the order be the nth P and P′ are connected by the sign-factor $(-)^{\frac{1}{2}n(n-1)}$.

The general theorem is: *If the first row of a semicirculant be* 1, 2, ..., $2m$, *the* $(m+1)$th *row be* $2m$, $2m-1$, ..., 1, *and the* $m-1$ *rows following each of these be obtained from them by cyclical change, right-handed in the first case and left-handed in the other, the semicirculant is equal to*

$$(-)^{\frac{1}{2}m(m-1)}(1+2+3+4+\ldots)(1-2+3-4+\ldots)\,\Delta^2 \qquad \text{(IV.)}$$

where Δ *is the determinant of the difference of the matrices of the two persymmetric determinants*

$$P'(m+3,\ m+4,\ \ldots,\ 2m,\ 1,\ 2,\ \ldots,\ m-1),$$
$$P(2m-1,\ 2m-2,\ \ldots,\ m+1,\ m,\ \ldots,\ 3).$$

A very curious special case is due to Mr. A. M. Nesbitt,* viz., the case where the elements are the even-placed coefficients in the expansion of $(a+b)^{2m+1}$ followed by $m-1$ zeros: the determinant is then equal to $2^{m.(2m+1)}$. For example, when $m=2$ we have

$$\begin{vmatrix} 5 & 10 & 1 & . \\ . & 5 & 10 & 1 \\ . & 1 & 10 & 5 \\ 1 & 10 & 5 & . \end{vmatrix} = 2^{10}.$$

From this is obtainable the equally curious result that *the determinant of the difference of the two persymmetric matrices*

$$\begin{array}{ccccc} \binom{2m+1}{1} & \binom{2m+1}{3} & \binom{2m+1}{5} & \cdots\cdots & \binom{2m+1}{2m-3} \\ . & \binom{2m+1}{1} & \binom{2m+1}{3} & \cdots\cdots & \binom{2m+1}{2m-5} \\ . & . & \binom{2m+1}{1} & \cdots\cdots & \binom{2m+1}{2m-7} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ . & . & . & \cdots\cdots & \binom{2m+1}{1} \end{array}$$

and

$$\begin{array}{ccccc} . & \cdots\cdots & . & . & \binom{2m+1}{0} \\ . & \cdots\cdots & . & \binom{2m+1}{0} & \binom{2m+1}{2} \\ . & \cdots\cdots & \binom{2m+1}{0} & \binom{2m+1}{2} & \binom{2m+1}{4} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \binom{2m+1}{0} & \cdots\cdots & \binom{2m+1}{2m-8} & \binom{2m+1}{2m-6} & \binom{2m+1}{2m-4} \end{array}$$

is equal to $2^{m(m-1)}$. (V.)

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* See *Educ. Times* (1904, Oct.), lvii. p. 419.

For example, when $m=4$ we have

$$\begin{vmatrix} 9-0 & 84-\ 0 & 126-\ \ 1 \\ 0-0 & 9-\ 1 & 84-\ 36 \\ 0-1 & 0-36 & 9-126 \end{vmatrix} = 2^{12}.$$

8. If the two originating circulants be of odd order, we may approximate to a semicirculant by taking one row more from the one than from the other. In this case also the new determinant is resolvable into factors, but now there is no factor repeated. Thus, taking the five-line instance we have

$$\begin{vmatrix} a & b & c & d & e \\ e & a & b & c & d \\ d & e & a & b & c \\ e & d & c & b & a \\ a & e & d & c & b \end{vmatrix} = \begin{vmatrix} a & b & c & d & e \\ e & a & b & c & d \\ d & e & a & b & c \\ . & d-a & c-b & b-c & a-d \\ . & e-b & d-c & c-d & b-e \end{vmatrix},$$

$$= \begin{vmatrix} a & b+e & c+d & d & e \\ e & a+d & b+c & c & d \\ d & e+c & a+b & b & e \\ . & . & . & b-c & a-d \\ . & . & . & c-d & b-e \end{vmatrix},$$

$$= (a+b+c+d+e \begin{vmatrix} a-e & b-d \\ e-d & a-c \end{vmatrix} \ \begin{vmatrix} b-c & a-d \\ c-d & b-e \end{vmatrix}.$$

It must be noted, however, that the process here followed is not applicable to the other instances without modifications, and that consequently we are not readily led by it to the formulation of the general result. The analogous difficulty in the case of even-ordered determinants was got over, as we have seen, by a preparatory process which brought about centrosymmetry: here this is impossible. The following theorem suggests a way out.

9. *In every odd-ordered semicirculant there is one column which is centrosymmetric (that is, reversible without change), and there is another, which, if deprived of its first element, has the same property.* (VI.)

If the order-number be $4m+1$, the middle row, being the $(2m+1)$th row of the first originating circulant, is

$$2m+2,\ 2m+3,\ \ldots,\ 4m+1,\ 1,\ 2,\ \ldots,\ 2m+1\ ;$$

and the $(2m+2)$th, being the first row of the second originating circulant, is

$$4m+1,\ 4m,\ \ldots,\ 2m+2,\ 2m+1,\ 2m,\ \ldots,\ 2,\ 1.$$

Now, as we have here $2m$ consecutive integers arranged in ascending order, and placed under them the same integers arranged in the reverse order, it follows that the two middle elements of the upper group have below them the same two middle elements in the opposite order: also as we have the first $2m+1$ integers arranged in ascending order, and placed under them the same integers arranged in the reverse order, it follows that the one middle element stands over the same middle element. This amounts to saying that the two rows must be partially represented thus—

$$\begin{array}{l} \ldots\ldots\ldots,\ 3m+1,\ 3m+2,\ \ldots\ldots\ldots,\ m+1,\ \ldots\ldots\ldots \\ \ldots\ldots\ldots,\ 3m+2,\ 3m+1,\ \ldots\ldots\ldots,\ m+1,\ \ldots\ldots\ldots \end{array}$$

Now by reason of the cyclical change from row to row, the elements immediately above $3m+1$ in the first of these two rows (that is, the middle row of the determinant) must be $3m+2$, $3m+3$, ...; and as the elements below are the same, the column in which these elements stand, viz., the mth, must be centrosymmetric. Similar reasoning makes clear that the column having $m+1$, $m+1$ for consecutive elements, viz., the $(3m+1)$th, is also centrosymmetric when deprived of its top element.

If the order-number be $4m+3$, the middle row and the row immediately following it are

$$\begin{array}{ccccccccc} 2m+3, & 2m+4, & \ldots, & 4m+3, & 1, & 2, & \ldots, & 2m+1, & 2m+2 \\ 4m+3, & 4m+2, & \ldots, & 2m+3, & 2m+2, & 2m+1, & \ldots, & 2, & 1 \end{array};$$

and these, if we only write the parts which are pertinent to the argument, are

$$\begin{array}{l} \ldots\ldots\ldots,\ 3m+3,\ \ldots\ldots\ldots,\ m+1,\ m+2,\ \ldots\ldots\ldots \\ \ldots\ldots\ldots,\ 3m+3,\ \ldots\ldots\ldots,\ m+2,\ m+1,\ \ldots\ldots\ldots \end{array}$$

so that it is now the $(3m+2)$th column which is perfectly centrosymmetric, and the $(m+1)$th which is approximately so.

10. If the perfectly centrosymmetric column thus proved to exist in a semicirculant of order $2m+1$ be advanced by cyclical change of columns to the first place, the operations performed in § 8 can be followed in exact detail. These are

$$\text{row}_{2m+1} - \text{row}_1, \quad \text{row}_{2m} - \text{row}_2, \quad \ldots\ldots, \quad \text{row}_{m+2} - \text{row}_m$$

and then

$$\text{col}_2 + \text{col}_{2m+1}, \quad \text{col}_3 + \text{col}_{2m}, \quad \ldots\ldots\ldots\ldots\ldots\ldots;$$

and the value found for the determinant is

$$\sigma . | M_1 - M_3 | . | M_2 - M_3 |, \qquad \text{(VII.)}$$

where σ is the sum of the elements, and the M's are matrices formed from the first m rows of the semicirculant, viz., M_1 consisting of the m consecutive columns beginning with the first, M_2 of the m consecutive columns beginning with the second, and M_3 of the last m columns reversed.

For example, in the semicirculant of the 9th order, it being the second column which is centrosymmetric, the first column is moved to the end, whereupon the first four rows stand thus—

$$\begin{matrix} 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 1 \\ 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ 9 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\ 8 & 9 & 1 & 2 & 3 & 4 & 5 & 6 & 7, \end{matrix}$$

and the factors of the circulant are seen to be

$$(1+2+\ldots+9)\begin{vmatrix} 2-1 & 3-9 & 4-8 & 5-7 \\ 1-9 & 2-8 & 3-7 & 4-6 \\ 9-8 & 1-7 & 2-6 & 3-5 \\ 8-7 & 9-6 & 1-5 & 2-4 \end{vmatrix} . \begin{vmatrix} 3-1 & 4-9 & 5-8 & 6-7 \\ 2-9 & 3-8 & 4-7 & 5-6 \\ 1-8 & 2-7 & 3-6 & 4-5 \\ 9-7 & 1-6 & 2-5 & 3-4 \end{vmatrix}.$$

11. From this we naturally pass to the semicirculants of odd order in which the two cyclical changes are effected in different directions. It is not necessary, however, to continue to give full details: the results alone will suffice.

First of all there is the theorem corresponding to that of § 9, viz., *In every odd-ordered semicirculant with opposite cyclical movements the middle column has the first element in the middle place, this being led up to by, the* $(m+1)$th, mth, $(m-1)$th, …, *3rd, 2nd elements and followed by the same: and the first column has the first element in the first place, this being followed by the* $(2m+1)$th, $2m$th, …, $(m+2)$th *elements and these repeated.* (VIII.)

This suggests the opening set of operations

$$\text{row}_{2m+1} - \text{row}_{m+1}, \quad \text{row}_{2m} - \text{row}_{m}, \quad \text{row}_{2m-1} - \text{row}_{m-1}, \quad \ldots,$$

after which we are led as before to the required value, viz.,

$$(-)^{\frac{1}{2}m(m-1)}\sigma . | M_1 - M_2 | . | M_1 - M_3 | \qquad \text{(IX.)}$$

where σ is the sum of the elements, and the M's are matrices formed from the first m rows, viz., M_1 consisting of the m consecutive columns beginning with the first, M_2 of the m consecutive columns beginning with the second, and M_3 of the last m columns in reversed order.

12. The foregoing investigations suggest others of a more general

character. For example, returning to circulants of the 4th order, we may form a determinant by taking *any* two rows from C (a, b, c, d) and *any* two from C (d, c, b, a). In every such case it is clear that $a+b+c+d$, $a-b+c-d$ would be factors as before; but it is not so readily seen what the co-factor would be. Investigation shows that it takes one of five forms, viz., 0, $(a-c)^2$, $(a-c)(b-d)$, $(b-d)^2$, $(a+b-c-d)(a-b-c+d)$: so that we have the general theorem: *Every determinant formed by taking two rows from* C (a, b, c, d) *and two rows from* C (d, c, b, a) *is resolvable into linear factors or vanishes.* (X.)

Similarly we find that *Every determinant formed by taking any three consecutive rows of* C (a, b, c, d, e) *and any two consecutive rows of* C (e, d, c, b, a) *is resolvable into three factors, one linear and two quadratic.* (XI.)

FURTHER OBSERVATIONS ON MIMICRY AMONG PLANTS.

By R. Marloth, M.A., Ph.D.

(Read May 31, 1905.)

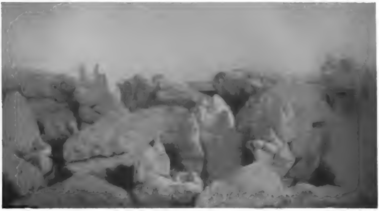
It will be remembered that a short time ago I read some notes before this Society referring to the rarely observed phenomenon of mimicry among plants. I took special care to point out that I looked upon many so-called cases of mimicry as mere speculation, but that on the other hand some instances which had come under my notice in the course of years appeared to be true mimicry. The word as used by me means that these plants are so well adapted to their surroundings that they escape the notice of herbivorous animals, especially of those feeding at night time. The most remarkable plant of this kind mentioned was *Mesembryanthemum Bolusii* Hook.

Travelling recently in the karroo I discovered another very striking example of such protective adaptation, which is specially interesting as the plant in question is not a near relative of those mentioned beforehand, but a species of Crassula.

Its specific name is *Crassula columnaris,* which indicates very well the shape of the plant as one sees it in cultivation, but is quite misleading with regard to the plant in its natural habitat, for there the plant is spherical. In shape and colour it is so similar to the brown pebbles among which it grows that one has much difficulty in detecting it. As an illustration of this I may be allowed to mention the following experience.

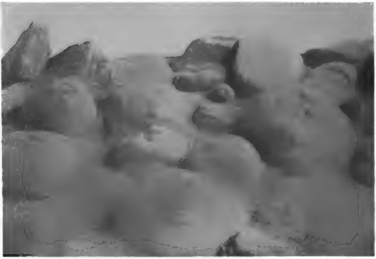
I had brought a dozen of these plants with some soil and pebbles with me to town, and having planted them in a box not larger than my hand, I sometimes asked visitors to my karroo plantations to count the specimens of koesnaartjes (that is their native name) in the little box. So far not one of my visitors has given me the total number at the first attempt.

It may be asked, as on the previous occasion, what is the use of this apparent hiding of the plant? Has it any enemies which threaten it? The answer to this question is as positive in this case as in the former one, for it is greedily devoured by goats and sheep whenever found, forming a nice juicy lump the size of a plum.



Photo] [*R. Marloth.*

CRASSULA DELTOIDEA L. f. Nat. size. (Five plants.)



Photo] [*R. Marloth.*

CRASSULA COLUMNARIS L. Nat. size. (Eight plants.)

That it is a tasty titbit to them is also evident from the fact that the Hottentots like to eat it themselves.

It is consequently obvious that those specimens which are best hidden on the bare veld, owing to their colour and shape, have the best chance of escaping destruction, while others which are more conspicuous on the ground will be more readily detected and eaten.

Quite a similar case is *Crassula deltoidea*, which forms small grey and white bodies on the granite hills of Little Namaqualand, and looks so similar to the fragments of granite among which it is at home that detection is as difficult in this case as in the other one.

As long as there was only the one instance known referred to by Burchell and Wallace, one might have tried to explain it away as a mere coincidence, but with ten such remarkable examples—and I have no doubt that more will be found when proper attention is paid to the matter—the theory of coincidences is hardly admissible.

In my paper on "Mimicry among Plants," a species of *Mesembryanthemum* was mentioned with white leaves (*Trans.* S. A. Phil. Soc., vol. xv., p. 101, line 4).

ON THE VARIATION OF THE HOURLY METEOROLOGICAL NORMALS AT KIMBERLEY DURING THE PASSAGE OF A BAROMETRIC DEPRESSION.

By J. R. Sutton, M.A., F.R.Met.S.

(With 2 Charts.)

(Read May 31, 1905.)

The present paper is the result of an attempt (1) to determine the variation of the hourly normals of the more important meteorological elements introduced by the passage of a barometric depression over Kimberley; and (2), incidentally, to learn something of the conditions prevailing in the depression itself.

In the absence of synoptic charts, any information under the second head can, of course, only be small in quantity. And I have no means of making it more definite because, for some reason, the Meteorological Commission has steadily, and at all times, refused to allow me to inspect any of their numerous records for this or any other purpose.

The information obtained under the first head is to be regarded as preliminary to a more extended treatment later on, and as indicating the direction of future research.

The ordinary depression may last for any time from a day to a week, and the winds generated may blow with any velocity from 5 to 35 miles an hour—and perhaps up to 50 miles an hour in occasional gusts. When they first become noticeable to all by reason of the strength of the wind, they set in with warm, discomforting gusts from the north or north-west, and pass away with cool, steady winds from south-west or south. They often bring light showers, but not often heavy rain. Frequently the approach of the centre, or trough, is heralded by clouds of dust; but it is remarkable that equally strong winds in the rear of the centre seldom raise any dust to speak of.

For the purposes of the present discussion, 105 separate depressions have been selected from the records of the six years 1898–1903, namely,

J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
6,	6,	5,	7,	11,	11,	7,	13,	10,	10,	10,	9,

and the hourly elements considered of the day upon which the centre, or trough, of the depression passed over, together with those of the day before and the day after.* Depressions in which the centres belong as much to one day as to another (*i.e.*, when of any four days containing the centre the pressure on the second day is about equal to that on the third, and the pressure on the first about equal to that on the fourth), have not been taken into account. They are equally important with the others, and will be considered at some future opportunity. In selecting our 105 depressions no attempt has been made to distinguish between one type and another, whether they be primary or secondary cyclones, "**V**s," or cols. Such a distinction, which belongs more especially to the province of synoptic meteorology, must also be left over for the present.

It is evident from Table 1 that the average pressure on the first days comes out, as it happens, almost exactly equal to the average pressure on the third days. This is so far fortunate that it gives us three quite central days in an average typical depression to study. It appears, further, from the Table, that the average pressures on the day before and the day after are about equal to the normal means throughout the summer half of the year, but that the normals are considerably the greater during the winter half.† The inference seems to be that, on the whole, during the summer a depression takes about three days to pass over, but that during the winter the depressions are larger and take longer to pass over. For in the winter months the front of a depression is evidently well defined upon the day before the passage of the centre.

In Table 2 the mean hourly values of pressure during the passage of a depression are given, and also the deviations from the normals hour by hour. It is remarkable that the depression does not in the least obliterate the ordinary diurnal variation. The absolutely lowest pressure comes about 4 p.m., and deviates at the same time by the greatest amount from the normal. Since the normal minimum also comes at the same time, it follows that the depression here simply exaggerates the normal conditions of pressure. The downward tendency of the barometer during the mornings of the day before and of the day itself causes the principal maximum of pressure to come fully half an hour earlier, namely, from 9 a.m. to 8.30 a.m., and in the same way retards it to 9.30 a.m. on account of the upward tendency during the day after. Also the secondary maximum, occurring normally at 11 p.m., comes an hour earlier on the first day, and perhaps an hour later both on the day and the day after. In the same way the afternoon minimum of pressure comes later on the first day and earlier on the third. The greatest variation is shown by the morning minimum of pressure. It comes half an hour later on the first day, nearly an hour later on the second, and becomes practically abortive on the third, showing itself, indeed, more as a retarded rise than an actual fall. The deviations of pressure increase from appreciably zero to about one-seventh of an inch in 40 hours, decreasing to zero again in the remaining 32 hours. The double amplitude in the average depression lasting three days is ·21 inch—that is, ·12 inch greater than the double amplitude of the ordinary diurnal oscillation; the double amplitude on the day in which the centre passes over is actually only ·02 inch greater than the normal.

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* These may be conveniently distinguished as the first, the second, and the third days.

† The monthly normal means of the various elements used in the text are taken from "An Elementary Synopsis, &c.," in *Trans.* S. A. Phil. Soc., vol. xiv., part 2. The hourly normals are from "The Determination of Mean Results, &c.," in *Report* of the S. A. A. A. S., vol. i. The first are obtained from four years' observations, the second from five. In consequence the means of the monthly and hourly averages differ a little.

The mean temperature of the first day is between one and two degrees higher than the normal; on the second day it is on the whole about half a degree higher still; while on the third day it is between three and four degrees lower than the normal. According to the hourly means of Table 4 the first day opens with a temperature slightly higher than the normal; there is then a gradual positively-increasing deviation throughout the day until sunset; for a few hours during the evening the temperature is falling rather more rapidly than is usually the case; but by sunrise of the second day the positive deviation is as large as before. There are signs of three maxima in the positive deviation of temperature on the second day, *i.e.*, just after sunrise, at noon, and just after sunset. How far they arise simply from the shortness of the record it is hard to say. Certainly the drop at 3 p.m. on the first day can scarcely be other than fortuitous.* After sunset of the second day the fall of temperature is rapid, a zero deviation being reached at midnight. From midnight onwards the negative deviation increases until it reaches nearly −6° at noon. During the succeeding afternoon this slackens somewhat to $-3^\circ\cdot5$ at 7 p.m., after which it increases again. Thus, on the whole, the effect of a depression is to exaggerate the diurnal curve of temperature somewhat on the first day, rather less on the second day, and to depress it on the third; that is to say, in the front of the depression the range of temperature is increased, in the rear the range is decreased, while along the trough it is not greatly affected. When we come to consider the variation in the aspect of the sky we shall find, perhaps, a reasonable explanation of the more rapid fall of temperature after sunset on the third day in the decreasing cloudiness and vapour-tension, and consequently increasing radiation. But the rapid fall after sunset on the first day is certainly not so easily explained. It has undoubtedly some connection with the variation in the velocity of the wind, to be presently referred to; but the nascent clouds proper to this part of the front of the depression, so far from acting as a blanket and checking the escape of heat from the lower air, would seem the rather to be actually themselves radiating cold to the earth.

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* A reference to Table 8 will discover a pronounced maximum in the frequency of rain at this time. A more extended record would probably to some extent smooth out this asperity as well as that of temperature.

The behaviour of the dew-point is not in the least like that of the temperature or pressure. Only from sunset of the first day to noon of the second is the deviation in the quantity of water vapour from the normal positive. The actual maximum positive deviation is at sunrise on the second day. Throughout the preceding 30 hours the quantity of vapour gradually increases relatively to the normal diurnal curve, hour by hour; in the following 42 hours the quantity as regularly decreases, saving one or two minor fluctuations not of any great consequence. The semi-diurnal oscillation of vapour-tension, of which the maxima come at about 10 a.m. and just before sunset, is on the whole more disturbed than is the case with the curves of the other elements. The times of the phases of the curve of vapour-tension in the depression will be best understood by reference to Table 6. The sunset maximum on the second day seems almost entirely smothered. We learn also from the Table that there is no great accession of water-vapour at any time during the passage of a depression, the greatest positive deviation from the normal tension not at any hour materially exceeding ·015 inches. In fact it is characteristic of a Kimberley cyclonic disturbance that such variation as there is in the quantity of water vapour obtrudes itself more in the dryness following the trough than in the prior dampness.

The deviation from the normal amount of cloud, though somewhat irregular, as might be expected, is similar to that of the quantity of water vapour. Starting from about the ordinary average at the opening of the first day, the deviation is altogether positive during the second day, and altogether negative during the third. Table 7 gives the respective annual means for the six hours of observation. The separate monthly means are not definite enough to be worth printing in full. By dividing the cloud types into cirriform, cumulus, and stratiform we get the following cyclonic variation in the mean monthly number of times observed :—

	Day Before.	Day.	Day After.
High-level clouds	8·0	8·4	6·6
Middle-level clouds	11·5	16·7	9·5
Low-level clouds	4·3	5·8	2·2

It appears from this that clouds of a cirrus type are not very much affected in quantity by the depression, and that the chief influence is upon the cumulus and other comparatively low-level clouds. It is worth notice that the variation in the frequency of rain is almost the same as that of the lower clouds. This rain frequency is such that in every 100 depressions rain is observed in 30 on the first day, in 44 on the second, and in 27 on the third; that is, on the day upon which the trough is passing over the chance of rain is half as great again as it is on the first day. During the three days we are considering the total rainfall is slightly less than three times the daily average of the year. The average daily amount is ·051 inch, while the average daily amount in the depression is ·046 inch, or 90 per cent. To make this, 94 per cent. of the daily average falls on the first day, 149 per cent. on the second, and only 27 per cent. on the third. It seems from this that the rain of the third day, when it does come, is only of about one-quarter the intensity of that of the first and second days.

It seems to be a fair inference from a comparison between the temperatures, dew-points, clouds, and rain of the day before, and the same elements of the day after the passage of a depression, together with the dust on the first and second days and its absence on the third, that the air currents have an upward tendency in front of the centre and a downward tendency in the rear.

Table 8 gives the number of times rain has been observed at any hour in the 315 special days under review, *i.e.*, in 105 depressions. We see from this that the relative hourly frequency of each day is very similar to that of the relative daily frequency. Also that in spite of the falling-off on the third day the diurnal curve of hourly frequency is not materially affected.

Table 9 gives the variation in the velocity of the wind in miles per day, month by month. The greatest daily velocity is attained in the spring, October being the month of maximum velocity, and also the month showing the greatest increase of velocity from the first day to the second. But because the daily velocity of the wind is greatest in the spring months it does not always follow that the wind attains its greatest force at the same time. Stronger winds are, in fact, occasionally experienced in July than in February. Moreover, the average velocity between 2 p.m. and 3 p.m. in July, on the second day, is 13½ miles per hour; the highest average velocity in February is less than 12½ miles per hour, between 5 p.m. and 6 p.m., on the second day. The greater daily velocity attained in the spring and summer months is simply due to the fact that during the winter the wind, however hard it may blow during the day, generally falls at sunset, whereas in the warmer months the high speed is maintained far into the night.

The diurnal variation in the velocity of the wind is as evident during the passage of a depression as it is at other times, although the shape of the curve is considerably modified. In general the average velocity changes from 5·0 miles an hour just after midnight to 4·4 miles an hour just before sunrise, and to 7·8 miles just after noon. During a depression the maximum comes rather later on all three days, the corresponding velocities changing according to Table 10:—

	Midnight.		Before Sunrise.		After Noon.
First day, from	4·4	to	4·2	to	9·0
Second day, from	4·4	to	4·4	to	13·1
Third day, from	6·3	to	5·7	to	8·0

We distinguish, then, in this way between general and cyclonic winds at Kimberley, so far as the class we are considering is concerned—that in front of the trough the range of velocity is greater, being lighter by night and stronger by day, while in the rear the range is smaller. In fact, the velocity at the midnight following the passage of the trough is half as great again as that twenty-four hours earlier. Some of the variations in question may be due in part to the fact that the winds observed are, to some extent, resultants compounded of normal winds and winds proper to the cyclone. Thus the normal wind between sunrise and noon is from some northerly direction; also the *cyclonic* wind in front of the cyclonic depression is likely, of itself, to be from some similar azimuth. We should expect here, therefore, an accelerated velocity. But the cyclonic wind in the rear of the depression is likely, of itself, to be from some southerly direction, and we should, therefore, expect a retarded velocity. Again the normal wind after sunset is from south-west to south, and this is also the likely direction of a cyclonic wind in the rear of a depression. Thus we get accelerated velocities after sunset of the second day, and, by the same token, retarded velocities after sunset of the first day. But such a line of suggestion leave unexplained, and in fact contradicts, the low velocities before sunrise of the second day and the high velocities before sunrise of the third. The rapid slackening of velocity after sunset of the first day relatively to the normal curve deserves attention if only because of the rapid cooling of the air at the same time.

Table 11 gives the total number of hours of wind from each of 16 directions in the 105 depressions (*i.e.*, 315 days) we are considering. There seem to be two prevailing directions on both the first and second days. On the first day directions in the first and second quadrants prevail; on the second day in the second and third quadrants. On the third day there is a single prevailing direction in the third quadrant; so much so that the wind is more peristent from the south-south-west than from all points having a northerly component, including east and west, put together. The actual diurnal variation of each direction is not materially affected at any time, *e.g.*, the third quadrant winds have their maximum frequency near the same hour of the afternoon on all three days as under ordinary circumstances.

The hourly components of wind-frequency are set out in Table 12. The north component commences the three days slightly negative (*i.e.*, it is slightly southerly), but changes to positive about 1 a.m., and remains so until the trough has passed, after which it is negative for the remainder of the period. It has positive maxima at 10 a.m. on the first day, and at 9 a.m. on the second, while the negative maxima fall at 7 p.m. on the first day, 6.30 a.m. and 7 p.m. on the third. The east component has positive maxima about an hour before sunrise, and negative maxima about 2.30 p.m. on each day. Thus the phases of the east component are practically unaltered by the depression, such changes as the Table reveals falling almost entirely upon the north component. This very important fact should be compared with a certain previous result that the east component curve at Kimberley is essentially a curve of temperature.

The angle ϕ in Table 12 represents the angle described by the resultant wind direction from the east round by north, west, south. This angle is greater than the normal between midnight and 10 a.m. on the first day, and between midnight and 3 p.m. on the second day, but it reaches its starting position on the second day not by boxing the compass but by backing after 4 p.m. on the first day. Throughout the whole of the second day the resultant veers continuously, and continues so to do until sunrise of the third day. It then backs by pretty well a right angle until 2 p.m., after which it approximates to a normal position.

The intensity and angular velocity of the resultant are displayed graphically in Fig. 1. In this diagram O is the origin of co-ordinates; and the resultant wind at any time is supposed to move from a given point on the curve towards O. Thus the line joining XX to O will represent the position and magnitude of the resultant wind direction (exclusive of velocity) between 7 p.m. and 8 p.m. It is pretty clear that the backing indicated by Table 12 between 4 p.m. and midnight of the first day, and between 6 a.m. and 3 p.m. of the third day, is only apparent, and that the extremity of the resultant steadily veers hour after hour. There are one or two minor irregularities which would most likely be smoothed out in a longer series. The whole portion of the curve, however, of the day before lies in a loop outside the origin to the north, and that of the day after is also wholly outside to the south-south-west. In the normal curve of Kimberley wind the veering, both in tabular and diagrammatic form, is complete, the origin being inside the curve. The orientations of the major axis of the normal curve, and of those in our diagram, are pretty nearly the same. Hence it seems that one of the most important variations introduced by the passage of a depression is to transfer the normal resultant-direction wind curve bodily to the north of the origin as the depression approaches, and to the south as the depression recedes. The vane tends strongly to the north-west of the normal direction during the morning of the day before, and still further westerly during the morning of the day of lowest pressure; it also tends strongly south-west of its normal position during the afternoon of the day after. At 8.30 a.m., *e.g.*, the normal resultant direction makes an angle of 62 degrees with the east and west line, whereas 31 hours before the passage of the centre it is 69 degrees, and seven hours before it is 100 degrees. An effect of this is that pronounced easterly directions are eliminated in cyclonic weather, although they are not, as it happens, replaced by very decided westerly directions.

In 1894–5 I made some comparisons between the barometric pressures of Kimberley, Durban, and Cape Town (as published casually in the *Cape Times*). It seemed from this that, on the whole, low pressures were experienced during the same day at Durban and Kimberley,* but from 20 to 40 hours earlier at Cape

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* The annual depression of the middle of July is experienced, on the whole, a day earlier at Durban than at Kimberley. See "Some Pressure and Temperature Results," &c., in *Trans.* S. A. Phil. Soc., vol. xi., pt. 4.

Town. I was unable to advance the investigation far for lack of material. In 1901, however, Professor J. T. Morrison, working on a better basis, quite independently, said that he had, with the help of Mr. C. Stewart, made a comparison of the daily pressures at Cape Town with those of Durban and Kimberley, and found that while the several places showed the same changes, Cape Town was almost invariably a day earlier than Durban.* Fig. 2 gives a specimen of the sort of evidence upon which my own opinion was founded. It is a diagram drawn by me in May, 1894, to depict the relation between the simultaneous changes of pressure at Kenilworth (Kimberley) and Cape Town. Durban pressures were added a few months later from some observations kindly sent me by Mr. Nevill; and within the last few weeks I have been able to add those for East London from observations kindly lent to me by the Harbour Board. The comparative charts for other months of 1894 and 1895 are equally conclusive, but May, 1894, is given in particular because in that month the *Cape Times* happened to print the daily observations without a break. The Kimberley pressures are plotted from observations made three times a day, at 8 a.m., 2 p.m., and 8 p.m.; Cape Town from two, at 8 a.m. and noon; Durban one, at 9 a.m. (Natal time); East London one, at 8 a.m. The diagram leaves very little doubt that crests and depressions appear at Durban and Kimberley on the same day, at East London slightly earlier on the average, and at Cape Town earlier still. This fact disposes of the idea (if such a random guess wanted disposing of) that depressions travel from west to east across South Africa. It also proves that they do not come from the Indian Ocean, nor from the north. Plainly they come inland from some southerly direction, by preference south-westerly. I have tried to carry an imaginary cyclone across a map of South Africa, which should account for Fig. 2, and in which the cyclonic winds, combined with the normal winds of Kimberley, should give the resultant winds of Fig. 1. A cyclonic path from about south-west to north-east accounts most satisfactorily for both diagrams.† Further research may improve the method and lay down the actual mean path of the centres of the depressions, and also may distinguish between the paths of the different varieties of depression, but it will certainly not greatly modify the mean direction here claimed.

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* See "Some Pressure and Temperature Results," &c., in *Trans.* S. A. Phil. Soc., vol. xi., pt. 4, p. li.

† To a certain extent bearing upon this is a remark of Sparrman:—"The people at this place [Zwellendam] pretend to have observed that the wind, when it blew from the south-east at the Cape, was always northerly with them; and that, when it had ceased raining at the Cape, they had still slight showers at Zwellendam." (Sparrman, "A Voyage to the Cape of Good Hope," second edition, 1786, vol. i., p. 223). The assertion has probably some foundation in fact.

TABLE 1.

MONTHLY MEANS OF BAROMETRIC PRESSURE DURING THE PASSAGE OF A DEPRESSION.

	Day Before.	Day.	Day After.	Normal Means.
	Inches.	Inches.	Inches.	Inches.
January	26·011	25·961	26·020	26·008
February	26·045	25·963	26·015	26·067
March	26·069	25·991	26·082	26·089
April	26·124	26·058	26·105	26·177
May	26·205	26·087	26·146	26·223
June	26·238	26·149	26·190	26·299
July	26·147	26·087	26·207	26·249
August	26·111	26·037	26·151	26·231
September	26·143	26·061	26·198	26·171
October	26·090	25·956	26·058	26·086
November	26·040	25·961	26·029	26·039
December	26·013	25·937	26·010	26·025
Year	26·103	26·020	26·101	26·139

TABLE 2.

HOURLY MEANS OF BAROMETRIC PRESSURE DURING THE PASSAGE OF A DEPRESSION.

Hour.	Averages.			Deviation from the Normal.		
	Day Before.	Day.	Day After.	Day Before.	Day.	Day After.
	Inches.	Inches.	Inches.	Inch.	Inch.	Inch.
M	26·147	26·060	26·052	+·004	−·083	−·093
I.	26·142	26·051	26·052	+·003	−·088	−·087
II.	26·135	26·042	26·052	·000	−·093	−·083
III.	26·130	26·035	26·055	−·002	−·097	−·077
IV.	26·129	26·032	26·063	−·005	−·102	−·071
V.	26·133	26·036	26·075	−·008	−·105	−·066
VI.	26·143	26·044	26·093	−·010	−·109	−·060
VII.	26·151	26·051	26·110	−·014	−·114	−·055
VIII.	26·159	26·058	26·128	−·016	−·117	−·047
IX.	26·159	26·057	26·135	−·020	−·122	−·044
X.	26·152	26·051	26·137	−·024	−·125	−·039
XI.	26·139	26·036	26·131	−·026	−·129	−·034
Noon	26·114	26·011	26·119	−·031	−·134	−·026
XIII.	26·087	25·986	26·104	−·037	−·138	−·020
XIV.	26·064	25·965	26·091	−·041	−·140	−·014
XV.	26·050	25·954	26·084	−·044	−·140	−·010
XVI.	26·041	25·948	26·082	−·048	−·141	−·007
XVII.	26·037	25·956	26·085	−·054	−·135	−·006
XVIII.	26·043	25·972	26·097	−·057	−·128	−·003
XIX.	26·050	25·992	26·112	−·063	−·121	−·001
XX.	26·062	25·014	26·128	−·065	−·113	+·001
XXI.	26·065	25·030	26·140	−·072	−·107	+·003
XXII.	26·068	25·044	26·147	−·075	−·099	+·004
XXIII.	26·065	25·049	26·150	−·079	−·095	+·006
	26·103	26·020	26·101	−·033	−·116	−·035

TABLE 3.

MONTHLY MEANS OF AIR TEMPERATURE DURING THE PASSAGE OF A DEPRESSION.

	Day Before.	Day.	Day After.	Normal Means.
	°	°	°	°
January	75·3	76·2	73·6	74·2
February ...	76·3	76·2	71·9	74·4
March	68·6	68·8	66·2	69·5
April	64·2	64·2	59·0	63·0
May	54·5	55·7	49·8	54·1
June	51·3	51·8	47·5	49·6
July	51·6	50·5	43·6	48·4
August	57·5	57·3	48·1	54·6
September...	62·8	64·6	54·3	62·1
October	68·4	69·0	62·3	65·3
November ...	72·2	74·2	68·1	71·0
December ...	76·2	76·8	71·2	74·4
Year	64·9	65·4	59·6	63·4

TABLE 4.

HOURLY MEANS OF AIR TEMPERATURE DURING THE PASSAGE OF A DEPRESSION.

Hour.	Averages.			Deviation from the Normal.		
	Day Before.	Day.	Day After.	Day Before.	Day.	Day After.
	°	°	°	°	°	°
M....	56·8	58·3	56·3	+0·5	+2·0	0·0
I.	55·8	57·1	54·5	+0·6	+1·9	−0·7
II..........	54·6	56·1	53·1	+0·6	+2·1	−0·9
III.	53·7	55·5	52·0	+0·5	+2·3	−1·2
IV.	52·9	54·9	50·9	+0·5	+2·5	−1·5
V..........	52·2	54·2	49·5	+0·7	+2·7	−2·0
VI.	52·3	54·3	49·0	+0·7	+2·7	−2·6
VII.	55·1	56·5	50·7	+1·4	+2·8	−3·0
VIII. ...	61·1	62·1	55·3	+2·0	+3·0	−3·8
IX.	66·8	67·3	59·7	+2·0	+2·5	−4·9
X..........	71·3	71·3	63·2	+2·4	+2·4	−5·7
XI.	74·6	75·1	66·4	+2·4	+2·8	−5·9
Noon ...	77·1	77·4	68·7	+2·5	+2·8	−5·9
XIII. ...	78·7	78·8	70·6	+2·4	+2·5	−5·7
XIV. ...	79·4	79·2	71·5	+2·5	+2·3	−5·4
XV.	78·6	78·8	71·7	+1·8	+2·0	−5·1
XVI. ...	78·3	76·9	71·0	+2·6	+2·2	−4·7
XVII. ...	75·1	74·8	68·2	+2·6	+2·3	−4·3
XVIII....	70·3	70·6	64·3	+2·3	+2·6	−3·7
XIX. ...	66·6	66·9	60·9	+2·2	+2·5	−3·5
XX.	64·0	64·4	58·5	+1·8	+2·2	−3·7
XXI. ...	61·9	62·0	56·3	+1·6	+1·7	−4·0
XXII. ...	60·5	59·7	54·4	+1·7	+0·9	−4·4
XXIII....	59·4	58·0	53·1	+2·0	+0·6	−4·3
	64·9	65·4	59·6	+1·7	+2·2	−3·6

TABLE 5.

MONTHLY MEANS OF DEW-POINT TEMPERATURE DURING THE PASSAGE OF A DEPRESSION.

	Day Before.	Day.	Day After.	Normal Means.
	°	°	°	°
January	51·6	51·2	41·7	52·4
February ...	54·5	53·3	52·2	52·6
March	52·3	52·2	47·2	55·2
April	49·3	49·2	44·7	50·4
May	41·6	41·1	37·2	39·5
June	34·7	35·5	34·6	34·8
July	31·8	32·9	30·8	33·8
August	37·4	36·4	33·8	35·0
September ...	37·2	37·3	34·0	37·9
October	41·4	41·6	37·9	42·2
November ...	40·4	42·2	41·5	44·3
December ...	51·7	48·9	41·7	50·1
Year	43·7	43·5	39·8	44·0

TABLE 6.

HOURLY MEANS OF DEW-POINT TEMPERATURE DURING THE PASSAGE OF A DEPRESSION.

Hour.	Averages.			Deviation from the Normal.		
	Day Before.	Day.	Day After.	Day Before.	Day.	Day After.
	°	°	°	°	°	°
M	42·2	43·3	40·4	−0·5	+0·6	−2·3
I.	42·5	43·6	40·3	−0·3	+0·8	−2·5
II..........	42·2	43·5	39·9	−0·4	+0·9	−2·7
III.	41·7	43·4	39·4	−0·7	+1·0	−3·0
IV.	41·5	43·2	39·0	−0·7	+1·0	−3·2
V..........	41·5	43·4	38·6	−0·8	+1·1	−3·6
VI.	42·2	44·0	39·0	−0·4	+1·4	−3·6
VII.	43·1	44·7	39·8	−0·3	+1·3	−3·6
VIII. ...	44·2	45·4	40·8	−0·3	+0·9	−3·7
IX.	45·1	46·0	41·4	−0·2	+0·7	−3·9
X..........	45·2	45·8	41·4	−0·2	+0·4	−4·0
XI.	45·2	45·6	41·5	−0·1	+0·3	−3·8
Noon ...	44·9	44·9	40·9	−0·1	−0·1	−4·1
XIII. ...	44·5	44·6	40·6	−0·1	0·0	−4·0
XIV. ...	44·3	44·1	40·3	−0·1	−0·3	−4·1
XV.	44·1	43·6	39·7	+0·1	−0·4	−4·3
XVI. ...	43·8	42·8	39·5	0·0	−1·0	−4·3
XVII. ...	44·5	42·7	39·8	0·0	−1·8	−4·7
XVIII....	44·5	42·3	39·5	+0·1	−2·1	−4·9
XIX. ...	44·7	42·0	39·6	+0·5	−2·2	−4·6
XX.	44·4	41·4	38·9	+0·6	−2·4	−4·9
XXI. ...	44·0	40·9	38·4	+0·7	−2·4	−4·9
XXII. ...	43·7	41·0	37·9	+0·6	−2·1	−5·2
XXIII....	43·5	40·8	37·5	+0·6	−2·1	−5·4
	43·7	43·5	39·8	0·0	−0·2	−3·9

TABLE 7.

MEANS OF CLOUD PERCENTAGE DURING THE PASSAGE OF A DEPRESSION.

Hour.	Averages.			Deviation from the Normal.		
	Day Before.	Day.	Day After.	Day Before.	Day.	Day After.
	%	%	%	%	%	%
VIII.	29	41	27	0	+12	− 2
XI.	25	37	26	− 3	+ 9	− 2
XIV.	40	51	26	+ 3	+14	−11
XVII.	35	40	22	0	+ 5	−13
XX.	33	33	13	+ 6	+ 6	−14
XXIII.	34	27	8	+11	+ 4	−15
	33	38	20	+ 3	+ 8	−10

TABLE 8.

TOTAL HOURLY RAIN FREQUENCY DURING THE PASSAGE OF 105 DEPRESSIONS.

Hour Ending	Day Before.	Day.	Day After.
	Times.	Times.	Times
I.	4	4	4
II.	3	3	3
III.	2	3	3
IV.	1	3	3
V.	—	4	4
VI.	2	3	3
VII.	—	3	3
VIII.	2	3	—
IX.	2	3	1
X.	1	2	—
XI.	2	4	—
Noon	3	3	—
XIII.	2	6	1
XIV.	3	5	1
XV.	8	6	1
XVI.	6	7	2
XVII.	4	11	3
XVIII.	4	9	2
XIX.	5	8	1
XX.	10	8	3
XXI.	6	7	6
XXII.	7	5	6
XXIII.	3	8	4
Midnight	2	6	2
	82	124	56

TABLE 9.

MONTHLY MEANS OF WIND-VELOCITY, IN MILES PER DAY, DURING THE PASSAGE OF A DEPRESSION.

	Day Before.	Day.	Day After.
	M. per D.	M. per D.	M. per D.
January …………	179·4	213·5	149·3
February …………	145·2	209·2	216·0
March ……………	149·1	158·1	131·0
April………………	115·0	182·9	118·2
May ………………	100·1	164·5	166·4
June ………………	128·8	166·2	121·0
July ………………	143·7	176·0	120·7
August ……………	167·7	222·1	126·7
September ………	148·5	228·3	173·7
October …………	166·4	261·2	196·0
November ………	147·1	219·6	163·2
December ………	166·7	212·3	166·2
Year ………………	146·5	201·2	154·0

TABLE 10.

HOURLY MEANS OF WIND-VELOCITY, IN MILES PER HOUR, DURING THE PASSAGE OF A DEPRESSION.

Hour Ending	Averages.			Deviation from the Normal.		
	Day Before.	Day.	Day After.	Day Before.	Day.	Day After.
	M. per H.	M. per H.	M. per H.	M. per H.	M. per H.	M. per H.
I.	4·4	4·4	6·3	−0·6	−0·6	+1·3
II.	4·4	4·4	6·1	−0·5	−0·5	+1·2
III.	4·3	4·5	5·9	−0·4	−0·2	+1·2
IV.	4·2	4·5	5·9	−0·4	−0·1	+1·3
V................	4·2	4·4	5·8	−0·2	0·0	+1·4
VI.	4·5	4·5	5·7	+0·1	+0·1	+1·3
VII.............	4·8	5·1	6·0	0·0	+0·3	+1·2
VIII.	5·6	6·3	6·5	+0·1	+0·8	+1·0
IX.	6·6	8·4	6·8	+0·1	+1·9	+0·3
X...............	7·8	10·1	7·1	+0·6	+2·9	−0·1
XI.	8·5	11·0	7·2	+0·9	+3·4	−0·4
Noon	8·6	12·1	7·4	+0·9	+4·4	−0·3
XIII.	9·0	12·9	7·7	+1·2	+5·1	−0·1
XIV.	8·9	13·1	8·0	+1·2	+5·4	+0·3
XV.	8·8	13·1	7·8	+1·1	+5·4	+0·1
XVI.	8·5	13·1	7·6	+1·2	+5·8	+0·3
XVII.	7·6	12·6	7·0	+0·9	+5·9	+0·3
XVIII.	6·4	10·8	6·4	+0·6	+5·0	+0·6
XIX.	5·6	9·0	5·5	+0·4	+3·8	+0·3
XX............	5·1	8·4	5·6	−0·1	+3·2	+0·4
XXI.	4·6	7·9	5·5	−0·7	+2·6	+0·2
XXII..........	4·5	7·5	5·6	−0·7	+2·3	+0·4
XXIII.	4·7	6·7	5·3	−0·5	+1·5	+0·1
Midnight......	4·6	6·5	5·5	−0·6	+1·3	+0·3
	6·2	8·4	6·4	+0·3	+2·5	+0·5

TABLE 11.

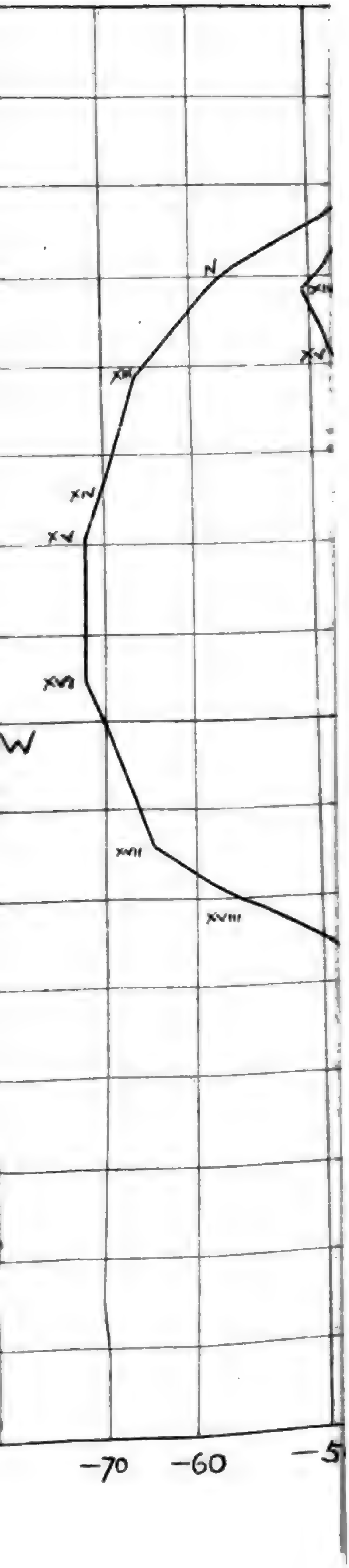
NUMBER OF HOURS OF WIND IN 105 DEPRESSIONS (315 DAYS) FROM EACH OF THE SIXTEEN STANDARD DIRECTIONS.

	Day Before.	Day.	Day After.
N.	256	202	40
N.N.E.	197	164	26
N.E.	207	157	45
E.N.E.	346	186	74
E.	173	72	46
E.S.E.	114	59	139
S.E.	97	56	203
S.S.E.	113	59	345
S.	67	110	350
S.S.W.	88	258	502
S.W.	81	234	374
W.S.W.	95	162	179
W.	86	112	57
W.N.W.	112	180	35
N.W.	152	198	43
N.N.W.	330	303	61

TABLE 12.

Components of Wind-Frequency.

Hour Ending	Day Before.			Day.			Day After.		
	N.	E.	φ.	N.	E.	φ.	N.	E.	φ.
	Hours.	Hours.	° ′	Hours.	Hours.	° ′	Hours.	Hours.	° ′
I.	− 1·648	+60·482	358 26	+19·313	+37·974	26 57	−49·829	−19·567	248 34
II.	+ 3·140	+56·226	3 12	+28·083	+36·665	37 27	−55·921	−19·753	250 33
III.	+ 6·309	+52·776	6 49	+28·605	+38·942	36 18	−58·600	−15·190	255 28
IV.	+10·515	+55·947	10 39	+31·759	+40·628	38 1	−61·050	−11·180	259 37
V.	+14·004	+58·324	13 30	+35·543	+46·359	37 29	−62·913	− 6·259	264 19
VI.	+17·167	+57·203	16 42	+35·588	+40·478	41 20	−61·095	+ 1·920	271 48
VII.	+24·581	+56·256	23 36	+44·595	+33·933	52 44	−64·476	− ·541	269 31
VIII.	+36·806	+45·657	38 53	+64·272	+15·352	76 34	−62·999	− ·880	269 12
IX.	+59·142	+22·846	68 53	+67·065	−12·176	100 17	−52·699	− 9·095	260 13
X.	+69·674	− 6·331	95 12	+66·625	−32·966	116 19	−50·214	−11·577	257 1
XI.	+70·872	−22·573	107 40	+59·138	−45·235	126 54	−44·664	−16·061	250 13
Noon	+63·743	−37·106	120 12	+49·590	−56·827	138 53	−47·202	−26·070	241 5
XIII.	+56·595	−45·226	128 38	+38·454	−66·296	149 53	−44·371	−31·451	234 40
XIV.	+48·186	−50·422	136 18	+25·913	−70·091	159 42	−48·850	−38·304	231 54
XV.	+41·153	−48·073	139 26	+20·561	−71·728	164 0	−54·334	−45·167	230 16
XVI.	+35·040	−44·089	141 31	+ 4·631	−71·798	176 19	−57·996	−39·127	236 0
XVII.	+27·425	−31·485	138 57	−14·115	−64·824	192 17	−65·628	−27·433	247 19
XVIII.	+23·927	−17·810	126 40	−21·127	−53·518	201 33	−70·883	−14·914	258 7
XIX.	+15·715	+ 3·696	76 46	−32·270	−41·336	217 59	−74·667	− 2·447	268 7
XX.	+15·921	+18·163	41 14	−43·890	−29·941	235 42	−74·438	+ 5·879	274 31
XXI.	+16·499	+31·026	28 0	−41·804	−25·372	238 45	−71·906	+18·603	284 30
XXII.	+16·339	+37·126	23 45	−43·123	−19·655	245 30	−70·131	+29·678	292 56
XXIII.	+20·659	+36·940	29 13	−43·612	−21·447	243 49	−66·388	+35·650	298 14
Midnight	+21·692	+40·064	28 26	−47·759	−20·941	246 19	−66·655	+38·385	299 50
	+713·456	+329·615	65 12	+332·035	−413·821	141 15	−1437·909	−204·901	261 53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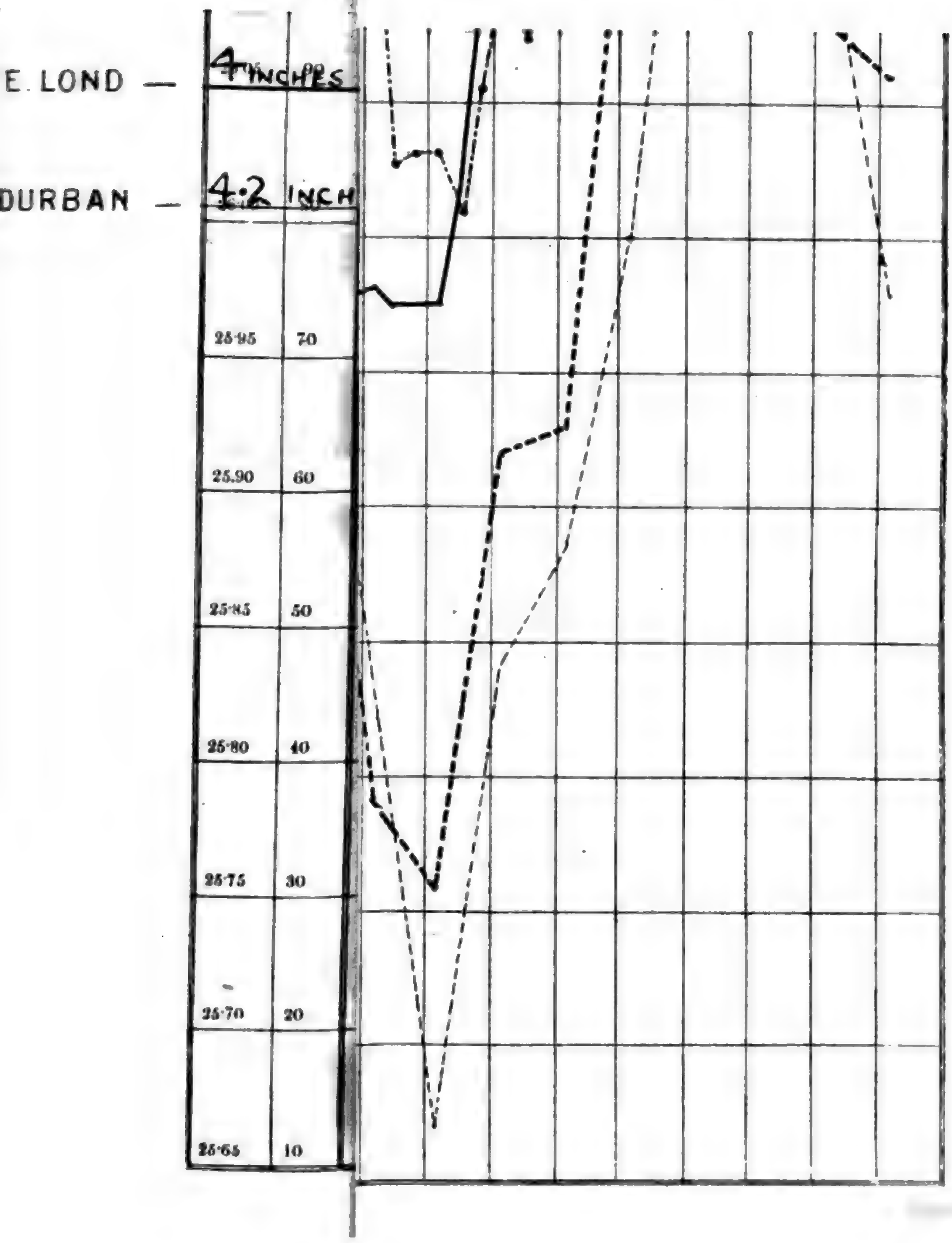
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25·65 10

THE VOLCANIC FISSURE UNDER ZUURBERG.

By A. W. Rogers, M.A., F.G.S.

(Read June 28, 1905.)

The general structure of the Zuurberg was described many years ago, first by A. G. Bain,* who drew a section (No. 11 of his paper) through the range in the area with which this paper deals, and secondly by R. Pinchin,† who made a carefully executed map and section of the same area. Both these geologists gave substantially correct explanations of the range, though the exaggerated vertical scale used by Pinchin obscures one of the main features of the mountains, that they were reduced to a comparatively level surface, on which the differences between the harder and softer strata are scarcely noticeable, before the great kloofs were carved out of them; the view of Bain that the Dwyka conglomerate was a contemporaneous volcanic rock, and Pinchin's opinion that it was a metamorphic rock, did not affect the general question of the structure of the range, as both authors knew that it lay conformably amongst the other beds forming the mountains.

During the past month I have been working along the southern flank of the Zuurberg, between Enon on the west and Bellevue on the east. The main part of the range is made of the Witteberg beds thrown into two or three great folds, the vertical height of which must be over 1,000 feet, and the limbs of these folds are at places themselves folded on a small scale, especially along the shale bands. The Dwyka conglomerate, accompanied by both the Upper and Lower shales, follows to the south, where the dips are very high in that direction, or rather some 5° to 20° west of south.

The great area of Uitenhage beds occupying the lower portion of the valleys of the Bushman's and Sunday's Rivers is ushered in by the Enon conglomerates, typically developed near Enon, where they form a belt of bushy country about three miles wide at the foot of the Zuurberg. Further east, along the road to the Zuurberg Pass, the conglomerates are much less conspicuous, and they can hardly exceed a width of half a mile. Along the Coerney River they widen out again, but near Sandflats they perhaps disappear completely at the surface, for the red and grey marls of the Uitenhage beds are almost in contact with the Witteberg quartzites, and I could only find a narrow band of conglomerate at a few spots. At Sandflats Station a borehole has been sunk within two miles of the Witteberg beds to a depth of 1,500 feet through sandstones and marls of the Uitenhage formation without striking any conglomerate; the beds penetrated lie practically flat, as is the case with the similar rocks at a few miles distance from the mountains further west. The exposures on or near the southern edge of the conglomerate show considerable southerly dips up to 45°. I cannot here go fully into the question of the relationship of the Enon beds to the marls and sandstones of the Uitenhage series, but one result of my recent journey has been to strengthen the opinion previously arrived at, that the three subdivisions (*i.e.*, Enon, Wood beds, Sunday River beds) of the series are not strictly successive deposits, but were partly contemporaneously formed under different circumstances. On this view, as on the supposition of a strict succession of the three subdivisions, the great variation in width of the Enon outcrop along the foot of the Zuurberg requires explanation, and the most probable explanation is that the area now occupied by the Uitenhage formation has been let down along a fault following approximately, but not exactly, the trend of the Zuurberg range. The increased but varying dip of the conglomerates towards their northern boundary supports this supposition, which is in accord with the observations of Mr. Schwarz * in the Willowmore and Uniondale Divisions, that the outliers of the Uitenhage beds there are faulted down against the older rocks to the north of them. The high dip of the Enon beds is expressed on Bain's section No. II., but the dips there given to the succeeding beds are much too high. In Pinchin's section (Fig. 4) the dip is also shown, but the relations of the conglomerate to the finer-grained deposits further south are wrongly given. The few sections available along one line of section, *e.g.*, from the Zuurberg Pass to the heights behind Coerney Station, certainly show that the southerly dip decreases regularly as one travels southwards, and that low northerly dips appear in places.

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* A. G. Bain, "Trans. Geol. Soc.," Second Series, vol. vii.

† R. Pinchin, "Q. J. G. S.," vol. xxxi., p. 106, and figs. 3, 4.

The northern boundary of the Bushman-Sunday Rivers' area of Uitenhage beds, then, we may take to be a fault. Mr. Schwarz noticed extensive shattering of the beds, either of the Uitenhage beds themselves or of the older strata against which they lie, along the fault lines in Willowmore and Uniondale, but this shattering seems to be greatly in excess of what one would expect along faults of no very great throw.

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* E. H. L. Schwarz, "Ann. Rep. Geol. Comm. for 1903," pp. 72–137.

Along the fault south of Zuurberg there are not only breccias somewhat similar to those of Uniondale and Willowmore, but a most remarkable band of lavas, accompanied by breccias of a more peculiar type than those mentioned above.

The country I am now dealing with is not a favourable one for geological observations; it is well covered with bush, which is in places quite impenetrable, and the rich development of soil hides the underlying rock over wide areas. The stream beds, too, although they lie in almost precipitous valleys and have very steep grades, are usually choked with a mixture of soil, fallen rock fragments, and vegetation. The following description is therefore necessarily incomplete, and may be somewhat modified by future work.

Travelling along the road from Coerney Station to Zuurberg Pass, after crossing the waterless Coerney River, one sees occasional roadside quarries in coloured marls, which dip south at 25° at one place, and near the lower end of the long hill in the valley trending south-east there are artificial exposures of the red Enon conglomerate dipping south at about 35°. The road lies about W.N.W., but the trend of the rocks is nearly east and west, and after an interval of some hundred yards the rock exposed in the ditch by the roadside is a highly vesicular lava, dull red outside and reddish-black within. In the bottom of the valley at this place a well has been dug, and most of the material thrown out is a heavy, dark, almost black, rather soft igneous rock, with many amygdales of some black substance. Near the surface the rock has a similar appearance to that seen along the roadside, and the apparent difference between the two rocks is probably due to weathering. As I have not yet had the opportunity of making a close examination of the lavas and other rocks of this fissure, I shall not go into the question of their petrological nature. Proceeding up the road the next outcrop is seen in the ditch about 400 yards above the well, and there we have greatly disturbed thin shales and limestones, belonging to the Upper Dwyka shales, and a few yards further on there is a road quarry in typical Upper Dwyka shales, which are here also highly disturbed; there follows the usual downward succession through the Dwyka conglomerate, Lower Dwyka shales, and the Witteberg formation (see Fig. 1). I could not get a close estimate of the width of the dyke-like body of amygdaloidal lava, but it is not more than 100 yards wide. From the well to the top of the ridge south of the road, but further west than the well, is a vertical height of about 300 feet; fragments of the lava are met with at intervals along the cattle tracks up it, and outcrops occur on the summit near some Kaffir huts. I followed this lava ridge four miles to the west, where it is cut through by the White River, but the lava is continued at least six miles further to the west behind the red conglomerates of Enon. On the farm Kremlin (on the eastern boundary of the Uitenhage Division) the lava dyke widens out to about 300 yards, and it is in contact on the north side with the Dwyka conglomerate, the Upper shales being cut out. On Slag Boom the volcanic fissure widens to about 800 yards, and the lava is accompanied by masses of red, yellow, and white tuff, and buff-coloured breccia containing a few pieces of quartzite that may have come from the Witteberg forma-

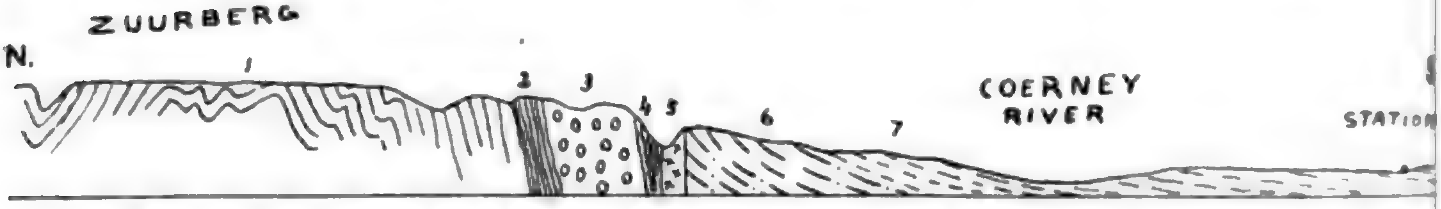

Fig. 1.—Section south from Zuurberg. Distance 8 miles. Vertical scale twice the horizontal.
1. Witteberg beds. 2. Lower Dwyka shales. 3. Dwyka conglomerate.
4. Upper Dwyka shales. 5. Volcanic rock. 6. Enon conglomerate.
7. Shales, &c., of Uitenhage beds.

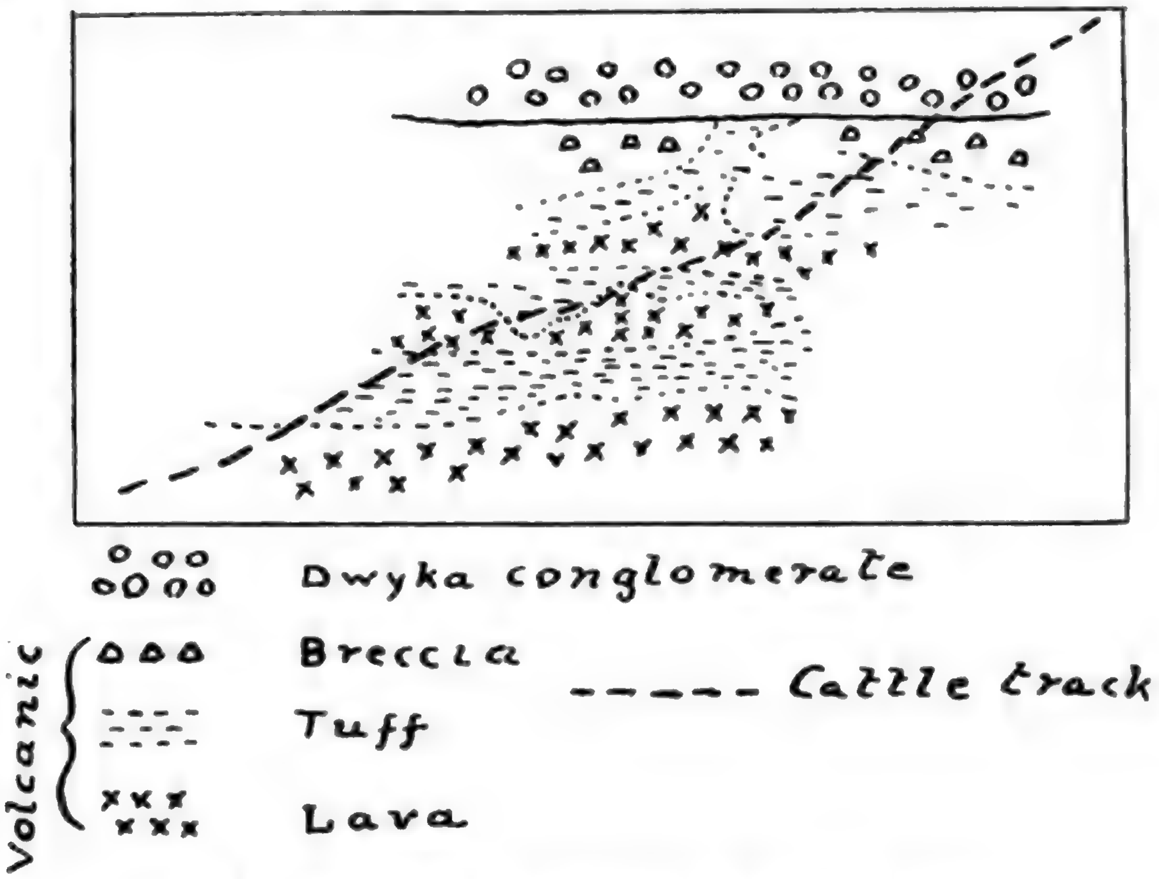

Fig. 2.—Plan of lava and fragmental rocks on Slag Boom.

tion. The lava in this wide portion of the fissure varies considerably; it is usually very full of amygdales, or it is vesicular owing to the infilling substance having been removed, but at places it becomes nearly compact. The relationship of the lava to the tuff in this locality, as in others to be mentioned below, is difficult to ascertain for want of outcrops, but on a part of the ridge near the south-east boundary of Slag Boom I was able to make the plan shown in Fig. 2. There is one general rule concerning the relationship of the two kinds of rock, tuff or breccia and lava, which fill the fissure; pieces of lava do not occur in the fragmental rocks, but pieces of the tuffs are often enclosed by the lava. In Fig. 2 it is obvious that the lava forms vein-like bodies in the tuff. On Slag Boom the volcanic fissure following the fault bends nearly north-west before again taking a westerly course through the Enon Mission ground. The height of the volcanic rocks at the top of the Kremlin-Slag Boom ridge is about 800 feet above the White River on Slag Boom, and the position of the volcanic fissure appears to be practically vertical (Fig. 3). I have not followed the rock westwards beyond Enon.

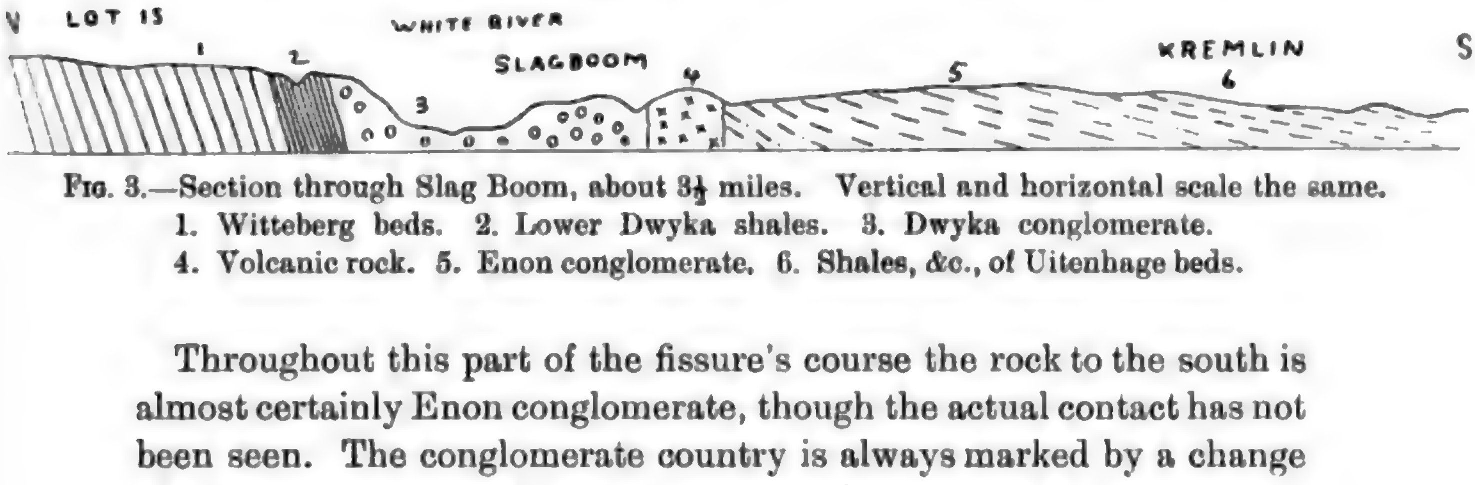

FIG. 3.—Section through Slag Boom, about 3½ miles. Vertical and horizontal scale the same.
1. Witteberg beds. 2. Lower Dwyka shales. 3. Dwyka conglomerate.
4. Volcanic rock. 5. Enon conglomerate. 6. Shales, &c., of Uitenhage beds.

Throughout this part of the fissure's course the rock to the south is almost certainly Enon conglomerate, though the actual contact has not been seen. The conglomerate country is always marked by a change of character in the soil, which becomes brighter red in colour and more or less heavily charged with rounded pebbles and boulders of quartzite derived from the conglomerate. Where exposures occur, as on Enon, the track from Slag Boom to Coerney, and the Zuurberg Pass road, the nearest rock to the lava on its south side is the ordinary red Enon conglomerate.

Turning now to the country east of the Zuurberg road, the volcanic rock trends about E. 10° S. towards the Coerney River, but beyond ascertaining the presence of the lava along this line I did not follow the fissure across this dense bush country. The lava itself seems to come to an end about a mile from the Coerney River, for I could find no trace of it in that valley or on the hill just to the west, where it should be seen if present. In the bed of the Coerney River, just north of the boundary between Buffel's Kuil and Coerney, there are outcrops of Dwyka conglomerate separated by an interval of 60 feet of swampy ground from the next outcrop to the south, which is a breccia of quartzite fragments, angular and sub-angular, set in a matrix with much calcite. This rock crops out for some 30 yards, when there is nothing else seen till one meets with the red Enon conglomerate dipping at an angle of 45° to S. 30 E. on the right bank of the river on Coerney farm. I was uncertain of the nature of this calcitic breccia until I found a very similar rock in close association with the tuffs, breccia, and lava of Duncairn and Mimosa.

Following up the fault line eastwards from Coerney River the lava is again seen about a mile from the river on the ridge to the north of a side valley descending westwards from Mimosa.* The width of the band of lava rapidly swells to some 1,000 yards, and this is maintained, or increased, as far as the main valley descending from the Nieuw Post escarpment through Mimosa, where the width is reduced to about 700 yards, but it again swells near the Duncairn boundary. The most easterly trace of the lava and tuffs I could find are on Duncairn, where they terminate bluntly towards the east without any apparent gradual reduction in width. The termination takes place on the divide between the valley in which Mr. Reed's boreholes are situated and the next kloof to the east. East of this I found a thickness of some 20 feet of quartzitic breccia between the Enon conglomerate and the Witteberg quartzites, and at one place, just east of the road to Waggwa, the transition from this breccia to the solid unbroken quartzite can be followed inch by inch in a distance of about 30 yards. In the above-mentioned valley descending from Mimosa to Coerney River and on the hill north of it there is some red tuff amongst the lava, but this part of the fissure is mainly filled with lava; in the northernmost head kloof of this valley, which almost reaches the Nieuw Post escarpment, a great body of tuff and breccia is met with. This mass of fragmental rock is quite 1,000 yards wide from north to south, and on the north it is probably in contact with the Witteberg quartzites, cutting out the Dwyka conglomerate and perhaps the Lower Dwyka shales, which were found both to the west and east. The shape of the tuff and breccia mass cannot be determined on account of the soil and bush, but it is probably a true volcanic neck in the form of an enlargement of the fissure we have been tracing. The Nieuw Post escarpment is a very steep face of Witteberg quartzites dipping at angles of 70°–80° S. 15° W. It ends below in bush-covered slopes, but along the cattle track from Mimosa to Nieuw Post there are several outcrops on the divide between the steep kloofs descending east and west. The northernmost 700 yards or so of the divide is sandy ground sprinkled with quartzite fragments and overgrown with bush. If the Dwyka conglomerate occurred here I think it would show itself, at least in fragments, as it does so in similar situations further west; the Lower shales do not make themselves so prominent, and they may or may not be present. South of the sandy ground one first meets with a brown micaceous sandy rock with bright green spots, a rock quite different from any known from the Dwyka series, and it certainly belongs to the very varied tuffs of the neck; then follow soft and quartzitic breccias with many fragments of Witteberg or other quartzite, then comes a peculiarly bright green breccia with fragments of sedimentary rocks in it, and this is followed by a soft pink tuff, which soon gives place to a red tuff with vesicles partly filled up, and this again to a soft red or white mottled tuff, which is followed by buff-coloured breccias with much quartzite in them; soft pink tuff is the last, and southernmost, fragmental rock of this neck. About 20 feet from the last outcrop of tuff the usual amygdaloidal lava is met with, but it contains a great quantity of tuff caught up when it was in a fluid condition.

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* The farm Mimosa, belonging to Mr. Walton, is not marked as such on the latest Divisional Map of Alexandria. It includes the farm called Thornleigh on that map and a part of Gorah (V. F. 7, 6), but I do not know its boundaries. Mimosa Station is on it.

A good number of outcrops of the lava were found by following the ridge along which the track goes to Mimosa, but there was no tuff seen on this ridge. The lava varies in compactness by the increase or decrease of the amygdales. The amygdales are of various minerals; calcite and chalcedony occur, but zeolites are more common. It was curious to find large chalcedony amygdales that look as if they might have come from the Vaal River.

In a garden at the end of this lava ridge in the main valley on Mimosa there is a larger outcrop of the lava than is usually met with, and in it are seen bands of more and less vesicular lava, without any definite dividing plane. There are also irregular bands of pipe amygdales; these are arranged perpendicularly to the layers of varying texture, and individually may reach a length of 3 inches. All these layers dip towards S. 10° W. at an angle of 20°. The occurrence of the pipe amygdales, which were noticed again on the Duncairn boundary though not in place, is very remarkable, for they have hitherto been found only in surface lava flows.

Going up the valley north of this garden one does not find outcrops till one passes a well sunk in the Dwyka conglomerate, above this only the Dwyka and Witteberg series are seen.

At the place where two kloofs join to form the main valley a few hundred yards east of the well, there is a small mass of buff and pink tuffs, followed to the south by lava with many tuff inclusions. This body of tuff seems to be a neck similar to, but smaller than, the large neck below the Nieuw Post escarpment.

A striking feature in the breccias is the absence of fragments of the Dwyka conglomerate, but this may be due to lack of observations. The breccias and tuffs are different from any that have been described from South Africa, but some of them show points of resemblance to tuffs of the Stormberg area, and others are not unlike some of the Saltpetre Kop breccias, so far as one can judge from hand specimens.

From this small neck I followed the lava up to the divide between Mimosa (Thornleigh) and Duncairn along a bush-covered slope and in the valley below; there were very few outcrops, but the Dwyka conglomerate was seen at one point in the stream bed, and nothing but pieces of lava and tuff or breccia above this outcrop. On the divide there is a short interval of covered ground between the Witteberg slope and the northernmost outcrop of lava; there is no room for the occurrence of the Dwyka conglomerate here, and probably the Lower shales are also cut out; south of the lava there is an area 500 yards wide on which tuff and breccias only occur; these resemble in general characters those on the large neck on the Nieuw Post track, but they include a coarse breccia of the type seen in the Coerney River bed. The red tuff in the south part of the neck is penetrated by lava, and numerous fragments of tuff occur in that rock, which occupies a belt of country some 500–700 yards wide south of the neck. To the east the amygdaloidal lava continues as a band of about 600 yards wide for another mile. There is much tuff mixed with the lava in places along this part of its course, and at one spot a borehole was put down 250 feet through a rock described to me as "pale-coloured sandstone," but of which I could not see a specimen. It was probably a tuff like the buff or pink tuffs of the larger necks. The lava is in contact with the Witteberg quartzites to the north along this part of its course, and where the lava ends the Enon conglomerate is in contact with the quartzites without the intervention of the Dwyka series. It is interesting to note that the front face of Witteberg quartzite on Duncairn is shattered into a breccia, in precisely the same manner as along the faulted contact with the Enon seen near the Waggwa road. The angular pieces of quartzite are embedded in a matrix of still further comminuted quartzite. There has been little addition of cementing substance, and the breccia is now as a whole a much more fragile rock than the solid quartzite owing to the want of a uniform cementation.

The total known length of the volcanic band is 19 miles, but it is probably continued further west than Enon.

The general habit of the rocks in this band proves that they occupy a nearly or quite vertical fissure, the only exception being the southerly inclined layers of different texture in the Mimosa valley, but this is a small outcrop in the middle of a band of 800 yards width. I searched every exposure of the Enon conglomerate for fragments of the lava and tuffs, but could find none, and the general form of the whole band is not consistent with the view that the volcanic rocks are contemporaneous with the early stages of the Uitenhage period; moreover, no volcanic intercalations have ever been found in those strata. It is also evident that the volcanic rocks in their present form have not been subjected to the forces that bent and twisted the Witteberg and Dwyka series to the north, for they show none of the incipient cleavage that characterises the latter rocks in the Zuurberg range. There remains no other view than that assumed early in this paper, that the volcanic rocks reached their present position by eruption along the line of fault between the Uitenhage beds and the Zuurberg.

The question as to whether the eruption accompanied the faulting, or followed it, is not an easy one to settle, but from the presence of rather broad bands of shattered rock both on the boundary of the volcanic fissure on Duncairn, and their presence further east where the fault alone is observable without the volcanic rocks, I am inclined to believe that the eruption accompanied the faulting. The similarity of the breccia seen near the Waggwa road to those of Uniondale and Willowmore, and the occurrence of the quartzite breccia at Duncairn in connection with the volcanic rock, lead to the suspicion that the brecciation of the rocks along the faults is due to some sort of explosive action, and that the breccias differ in this respect from the usual type of broken rock which is developed on a comparatively small scale along many faults.

Hitherto volcanic rocks have not been found to accompany faults in this Colony. The only possible exception yet described is the pipe of melilite-basalt on Spiegel River, which is situated very near the northern boundary of the Heidelberg outlier, and this boundary is probably a fault. The distribution of the scattered pipes of the Kimberley and Saltpetre Kop type has not been connected with any structural lines of the country, nor have the Stormberg volcanic necks any definite arrangement,* though their south-eastern limit in

---

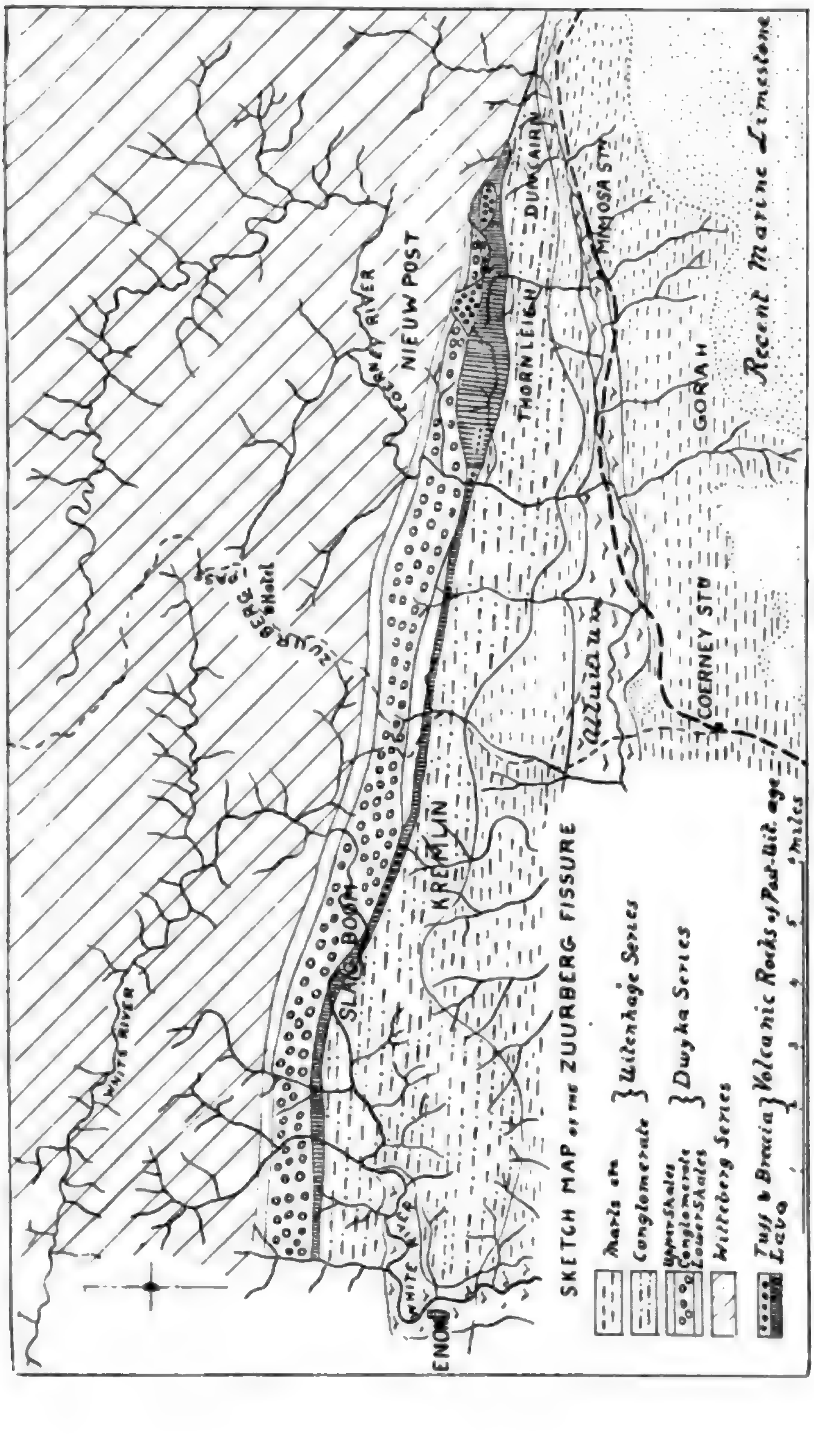
* Du Toit, "Ann. Rep. Geol. Com. for 1904," map.

Matatiele runs more or less parallel with the Pondoland coast and the post-cretaceous faults on that coast.

In East Africa the recent volcanic rocks are connected with the downthrown areas called the Rift Valleys, but they present no precise parallel with the Zuurberg volcanic belt.

There can be no doubt that the eruptions along the Zuurberg fault took place after the deposition of the Uitenhage beds, which are of Lower Cretaceous age, but the only later limit which can at present be set to the event is laid down by the fact that the tops of the volcanic ridges are cut down to a surface which was once continuous with the Zuurberg slope; and these tops are still capped in places by gravel similar to that on the main slope, from which they are now separated by valleys several hundred feet deep. No trace of lava flows or beds of ash ejected from the fissure has been found on Zuurberg or the country to the south. If such materials were ever thrown out they have long since been swept away. Although there is no direct evidence of surface outflows, the highly vesicular character of the lava shows that there must have been open access to the air, otherwise the water vapour could not have expanded so freely. The total absence of recognisable lava fragments in the breccias and the relationship of the tuffs and lava show that the violent explosions which produced these breccias were succeeded by the more gentle rise of the lava. The explosions occurred not only at the well-defined enlargements of the fissure but at so many other places, as shown by the presence of breccia and tuff at intervals throughout, that we may regard the whole line as having once been their site, but the direct evidence of this is now lacking owing to the rise of the lava and its replacement of the fragmental rock.

As to the origin of the material forming the tuffs and breccias little can yet be said, but quartzites like those of the Witteberg series are the most abundant recognisable rocks in them.


SKETCH MAP of the ZUURBERG FISSURE
Marls etc
Conglomerate
Uitenhage Series
Upper Shales
Conglomerate
Lower Shales
Dwyka Series
Witteberg Series
Tuff & Breccia
Lava
Volcanic Rocks of Post-Uit. age
5 miles
WHITE RIVER
ZUURBERG PASS
Hotel
COERNEY RIVER
NIEUW POST
DUNCAIRN
MIMOSA STN
THORNLEIGH
GORAH
Recent Marine Limestone
Alluvium
COERNEY STN
KREMLIN
SLAG BOOM
WHITE RIVER
ENON

SKETCH MAP OF THE ZUURBERG FISSURE.

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TRANSACTIONS

OF THE

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ON THE SOUTH AFRICAN DINOSAUR (*HORTALOTARSUS*).

By R. Broom, M.D., D.Sc., C.M.Z.S.

(Read June 28, 1905.)

Plate III.

The genus *Hortalotarsus* was founded by Seeley * in 1894 on the remains of a small Dinosaur discovered at Barkly East, Cape Colony. Though most of the skeleton was apparently in the rock when the fossil was first discovered, it was destroyed by a charge of gunpowder, and all that now remains is the portion of the right limb described by Seeley. A very good description is given of the remains, but the figures are not very good. In Fig. 2 the fibula is represented as a very slender rod except at its lower end, and one would be led to believe by the manner of shading that both the fibula and the tibia are completely exposed. In reality much of the fibula and a fair proportion of the tibia are hidden by matrix. The tibiale and fibulare are much too small. Fig. 3 is rather inaccurately drawn. In the plate accompanying this paper I have given a slightly restored view of the tibia as seen from the inner side with the tibiale in position (Fig. 5). A restored outline of the proximal end of the tibia shows that it agrees closely with the tibia of *Massospondylus* as figured by Seeley. Fig. 7 shows the posterior aspect of the lower end of the tibia and fibula with the tibiale and fibulare, and Fig. 8 the lower aspect of the same bones. Though the tibiale and fibulare are not anchylosed to the tibia and fibula they fit closely to them, and there has probably been very little, if any, movement between them. The small bone which Seeley regards as the intermedium is quite rudimentary, but is probably rightly regarded as the intermedium. The fourth toe is fairly complete, and shows very well the structure of the proximal phalanges. The first phalanx has the proximal surface slightly concave for the head of the metatarsal, and no doubt had some degree of lateral movement. The more distal phalanges have saddle articulations.

---

* H. G. Seeley, "On *Hortalotarsus skirtopodus*, a new Saurischian Fossil from Barkly East, Cape Colony." Ann. Mag. Nat. Hist. 14. 1894, p. 411–419.

The following are some of the principal measurements:—

Length of tibia	199 mm.
Antero-posterior measurement of proximal end of tibia	56
Width of distal end of tibia	39
Length of 3rd metatarsal	100
,, 4th ,,	87
,, 1st phalanx of 4th toe	28
,, 2nd ,, ,,	22
,, 3rd ,, ,,	18
,, 5th metatarsal	42

There has recently been presented to the South African Museum, Capetown, by Mr. Alex. Moir, a block of sandstone from Ladybrand, O.R.C., containing the remains of a considerable part of the skeleton of an immature *Hortalotarsus.* The bones to a large extent have been dissolved out leaving casts, or where preserved they are in most cases too friable to be satisfactorily developed. The bones are at the ends imperfectly ossified, the animal being evidently not quite mature. When allowance is made for this, however, the agreement of the bones with those of *Hortalotarsus skirtopodus* is so close as to leave no doubt that this specimen belongs to the same genus, and very little doubt that it is the same species. The following parts of the skeleton have been displayed: Eleven dorsal and six caudal vertebræ, a few ribs and some abdominal ribs, part of the right scapula, both ilia, the right being fairly well preserved, the right pubis and ischium, the right femur and fibula, the tarsus, and the perfect right pes.

The dorsal vertebræ are only represented by imperfect casts, and those preserved are fairly similar. The best preserved is the 4th last. It is a little longer than high. The centrum is 33·5 mm. in length, and considerably broader than high. When viewed from the side the lower border is seen to be moderately concave. The arch is not yet quite anchylosed to the body. The spine is comparatively low and rather long antero-posteriorly. The zygapophyses are long, and appear to have been largely articulated with one another. From the anterior to the posterior zygapophysis the vertebra measures 48 mm. There are indications of a transverse process in the position shown in the Fig.

The caudal vertebræ are much shorter and a little higher than the dorsals. Well-developed chevrons are found attached.

Only a few portions of true ribs are seen, but there are a number of fairly well-preserved abdominal ribs. It seems probable that the plastron has consisted of a median series with an outer series on either side.

The right ilium is perfect except a portion of the crest. In contour it agrees pretty closely with the ilium of *Palæosaurus*. There are well-developed pubic and ischiac processes, but they have not been fully displayed owing to the nature of the specimen. The crest as preserved measures 130 mm. This, however, is probably the full length. The anterior border of the ilium is more open than in *Anchisaurus*. The contour of the posterior border also differs a little from that of *Anchisaurus*.

The pubis and ischium of the right side are fairly well preserved, but considerably crushed and somewhat displaced. They are figured in their relative positions to each other as found, but not exactly in their relative positions to the ilium.

The pubis approaches rather more nearly the Zanclodont type than the type of *Anchisaurus*. The distal extremity is moderately thick but evidently flattened. The proximal end has an inferior notch as in *Zanclodon* and *Massospondylus*, but the bone is less expanded below the notch than in these genera.

The ischium is a moderately stout bone, probably not unlike that of *Massospondylus*, but it is too much crushed to enable one to make a careful comparison.

The femur is fairly well preserved and its anterior surface has been displayed. The upper and lower ends are imperfectly ossified, but the bone seems to have resembled fairly closely the femur of *Anchisaurus*. The lateral trochanter is situated above the point of union of the upper and middle thirds of the bone; in this resembling *Anchisaurus* but differing from *Massospondylus* or *Zanclodon*. The proximal trochanter is very slightly developed.

The fibula is comparatively slender, but stouter proximally than distally.

The tibia has not been displayed as the foot is folded on it.

The foot is strikingly like that of *Anchisaurus*. The bones are very badly preserved, but the casts show pretty satisfactorily most of the details.

The tarsus consists of two proximal elements—the tibiale and fibulare. The intermedium was probably not fully ossified in this immature specimen. The distal row of the tarsus is represented by two bones, apparently tarsalia 3 and 4.

The metatarsals, though rather more slender, are essentially similar to those of *Anchisaurus*. Proximally they overlap in like fashion. Distally the ends are less expanded, and the middle metatarsal is relatively a little longer than in *Anchisaurus*.

The digits are proportioned almost exactly as in the American genus. The ungual phalanx is more developed in *Hortalotarsus*, but in nearly every other respect the resemblance is so close that had the foot alone been discovered it would have been impossible to have distinguished the specimens generically.

The following are some of the principal measurements :—

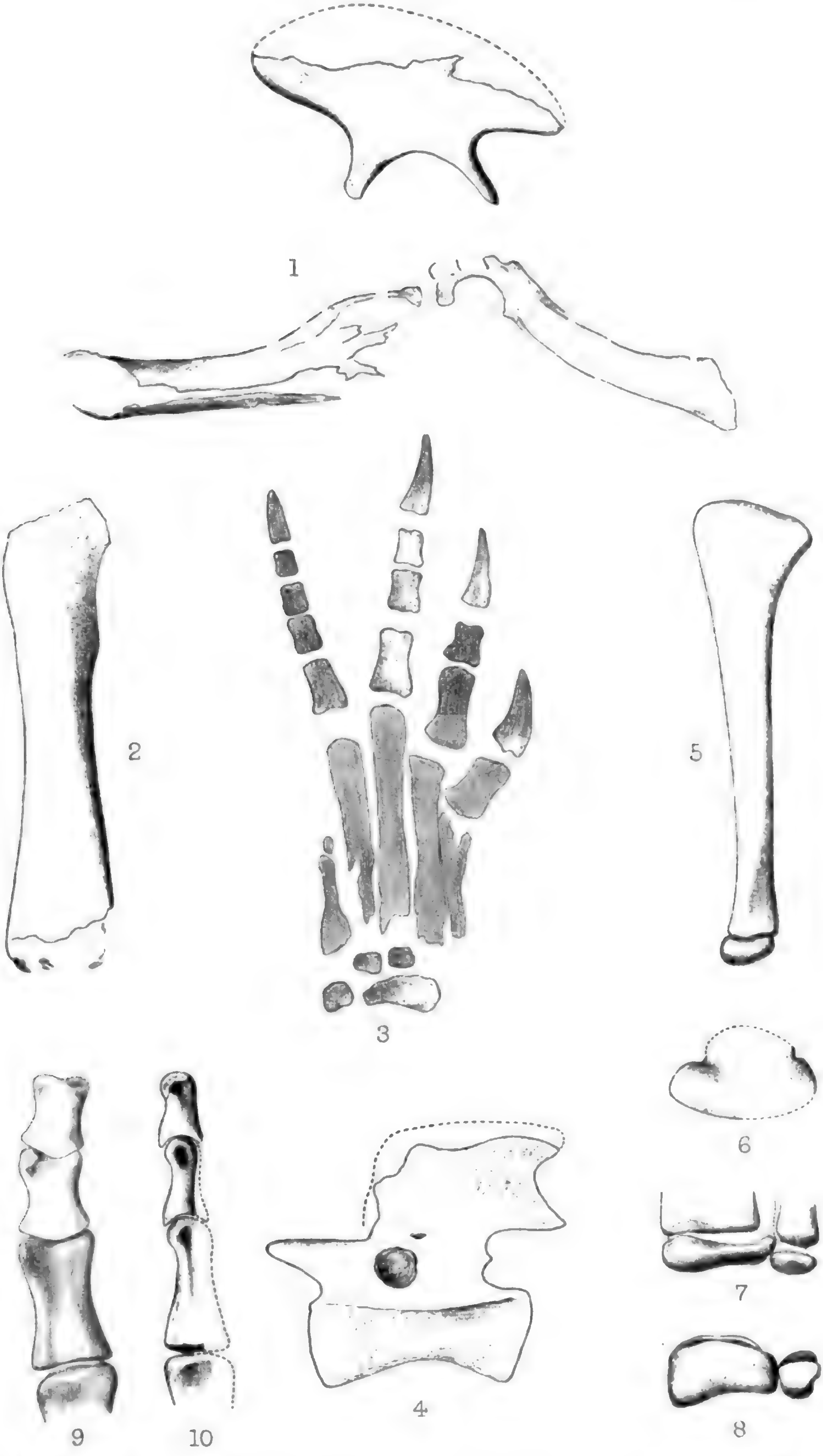
Length of ilium	about	130 mm.
,, femur	,,	200
Breadth of femur at lower end		43
Length of fibula		180
,, 1st metatarsal	about	55
,, 1st phalanx of 1st digit		28
,, 2nd ,, ,,		36
,, 2nd metatarsal	about	80
,, 1st phalanx of 2nd digit		32
,, 2nd ,, ,,		18
,, 3rd ,, ,,		33
,, 3rd metatarsal	about	90
,, 1st phalanx of 3rd digit		30
,, 2nd ,, ,,		18
,, 3rd ,, ,,		15
,, 4th ,, ,,		30
,, 4th metatarsal	about	82
,, 1st phalanx of 4th digit		25
,, 2nd ,, ,,		16
,, 3rd ,, ,,		14
,, 4th ,, ,,		14
,, 5th ,, ,,	about	21
,, 5th metatarsal		45

The vertebræ and most of the bones of the skeleton are hollow as in *Anchisaurus*, and the agreement otherwise is so close that there seems little doubt that *Hortalotarsus* must be placed in the family Anchisauridæ of Marsh.

Plate references will be found overleaf,
facing the plate.

REFERENCES TO PLATE III.

Fig.
1. Right ilium, pubis, and ischium of *Hortalotarsus skirtopodus*, × ·31.
2. Right femur of *H. skirtopodus* (anterior view), × ·37.
3. Right hind foot of *H. skirtopodus* (under view), × ·33.
4. Lower dorsal vertebra (probably 4th last) of *H. skirtopodus*, × ·9.
5. Right tibia and tibiale of *H. skirtopodus* (type), × ·3.
6. Proximal end of right tibia of *H. skirtopodus* (type), × ·36.
7. Tibiale and fibulare with lower ends of tibia and fibula (posterior), × ·33
8. ,, ,, ,, ,, ,, (inferior), × ·33
9. 1st, 2nd, and 3rd phalanges of the type specimen (inferior), × ·65.
10. ,, ,, ,, ,, ,, (side), × ·64.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R. Broom del.
West, Newman lith.

HORTALOTARSUS SKIRTOPODUS, *SEELEY.*

NOTES ON SOME RECENTLY REDISCOVERED INSCRIBED STONES BEARING ON THE HISTORY OF THE CAPE COLONY.

By W. L. Sclater, *Director of the South African Museum.*[*]

(Read June 28, 1905.)

I.—J. van Plettenberg's Boundary Stone.

In the year 1778, in consequence of complaints from burghers living on the eastern frontier of the Colony, the Governor, Joachim van Plettenberg, resolved to make a visit to the borderlands of the Colony and investigate the condition of affairs there. Leaving Cape Town on September 3, 1778, he travelled to Graaff Reinet with ox-waggons and saddle-horses. Thence, crossing the Sneeuwberg to the north, he descended the valley of the Zeekoe River to a point about 18 miles due west of the present village of Colesburg. Here on October 4th, some 200 yards from the bank of the stream, he erected a "baaken," or boundary beacon, to mark the extreme north-eastern boundary of the Colony.

A month later, on November 6th, the Governor arrived at the bay where the Keurboom River falls into the sea, now known as Plettenberg's Bay. Here a stone pillar prepared in Cape Town, having the arms of the United Provinces, the monogram of the Dutch East India Company, the arms of the Governor, and a suitable inscription, which had been conveyed to its destination on the waggon of Jacob Joubert, was placed in position, and here it has remained ever since. It has recently been enclosed by a stone wall in order to preserve it, and will be found figured in Moodie's "History of the Battles and Adventures of the British, Boers, and Zulus," vol. i., p. 62, published in 1888.

The above facts will be found in the new edition of Mr. Theal's "History," vol. ii., pp. 149–154, while a complete transcription of a diary of the journal of Plettenberg's journey in the original Dutch, preserved in the Colonial Archives, has been recently published by the same author in a "Collection of Important Historical Documents."*

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[*] For previous papers see these *Transactions*.

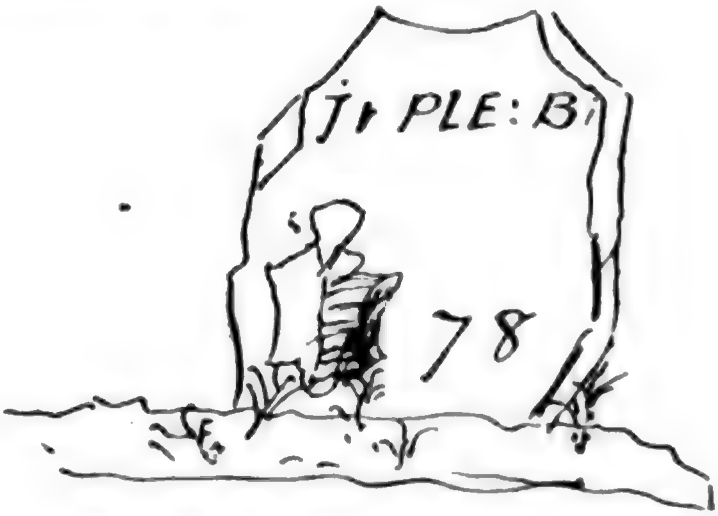
Barrow ("Travels in the Interior of South Africa," i., p. 255, 1803) visited the north-eastern portion of the Colony in October, 1797. He states that Plettenberg's beacon was then already thrown over and broken up by the Bushmen.

The next reference I have met with in regard to the beacon is a letter addressed by a Mr. C. J. Kemper to the *Grahamstown Journal* in 1843. I have not been able to see the original, but the following is a copy kindly obtained for me by Mr. Murray, the donor of the stone to the Museum, who obtained it from Mr. L. Kemper, son of the original writer. The following is a transcription of the letter:—

"COLONIAL BEACONS.

"LICHTENSTEIN, *September* 16, 1844.

"*To the Editor.* SIR,—Seeing in your esteemed *Journal* a sketch of a land beacon, supposed by Mr. James Howell to be that of Governor van Plettenberg, I am induced to send you a sketch from a drawing of one which I took on a journey in the year 1830 on the other side of the Zeekoe River, not far from the place of the Field Commandant Tjard van der Walt:—



This worthy old gentleman informed me there was a stone on the flat a short distance from his residence called "Plettenberg's Baaken," and that it had engraved upon it some figures and his name. Feeling much interest in this statement, I requested the Commandant to show me this stone, which he did, and I then took, in his presence, a sketch of it and the surrounding hills.

---

* "Belangrijke Historische Dokumenten verzameld in de Kaap Kolonie en elders door," George McCall Theal, LL.D., No. I., Kaapstad, 1898.

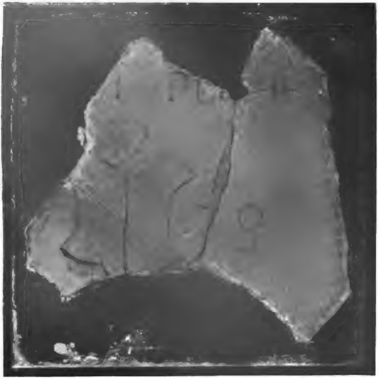
"I think this must be the beacon erected by Governor van Plettenberg. The armonial escutcheon is that of his family, and corresponds to the period indicated by the figures, Joachim van Plettenberg being Governor of the Colony in the year 1778.

"I remain, &c.,

(Signed) "C. J. KEMPER.

"N.B.—There must be an error given in Mr. Howell's communication in the figures 98, as in 1798 Sir Francis Dundas was Lieut.-Governor."

About fifteen years ago Mr. Murray, a surveyor who, with his brother, occupied the farm Quaggasfontein in the Colesberg district, made a careful search for the beacon, which had apparently disappeared. After some days he succeeded in finding part of the stone with a coat of arms on it, and finally collected several other fragments, though even now it is by no means complete. Mr. Murray



believes that the stone had been thrown down and broken many years ago, probably by a native shepherd, as pieces of it were black and had evidently been heated in a fire to roast meat on, as is the custom with Hottentots.

The pieces of the stone were brought to the homestead, and have remained there ever since until a few weeks ago, when they were most generously presented to the South African Museum by Messrs. Murray Brothers, of Quaggasfontein.

The stone shows the coat of arms, which is a very simple one. I have not been able as yet to trace the arms of van Plettenberg, but I have no doubt that the shield is his; the second half of the date 78 is plainly shown, and also a portion of the name of the Governor.

II.—Post-Office Stone in the Castle Wall.

My attention has recently been drawn to an inscribed stone built up in the outer wall of the Castle. It is about 10 feet above the level of the grassy glacis on the bastion, facing due west to the right-hand side of the main gateway. The stone is so placed that the principal inscription is upside down, so that it was evidently merely used to assist in forming the wall of the Castle, and not with a view to the preservation of the inscription.

There can be little doubt that the stone has been in this position since the original building of the Castle, which was begun in 1666 and finished in 1679.

My attention was first drawn to the existence of the stone by Major H. Sutton, of the Grenadier Guards, who has lately been occupying a position on the staff in Cape Town; and I am indebted to Mr. H. Amon, of the Army Pay Department, for the very clear and excellent photograph of the stone here reproduced. The inscriptions appear to me as follows:—

JOHN · ROBERTS.
COMMAVNDER · OF
THE · LESSER · JAMES.
AR: Y^{E} · $8^{\underset{+}{\text{TH}}}$ DECEM: DE: Y^{E}
26: 1622 + LOVK · WITH · THIS
LINE . FOR LETERES
HENR MANC.

The second inscription seems to me :—

JAMES . BVRGES . M$^{R.}$ OF . THE
ABIGAIL + AR : Y^{e} [17]
DEPAR + Y 26
OF DECEMBAR
1622

Through the kindness of Mr. William Foster, of the India Office in London, I have been able to learn a few particulars about the voyages of these two ships.

He writes : "The *Lesser James* (450 tons), commanded by John Roberts, left Batavia homeward bound in the last days of August, 1622. In his commission, which is still preserved at the India Office, London (O.C. 1074), Roberts was directed, amongst other things, to look for letters at Table Bay.

> "'When you arive in the Bay of Saldania, you shall make search for letters ; and in like mannor, at your departure thence, leave behinde you in writinge fitt remembrances of all matters needfull.'"

No further account of this voyage has been found, but the ship reached England in the middle of June, 1623.

The *Abigail* was a new ship, which sailed from England for Batavia in 1622. The journal of the Master, James Burgess, is still preserved in the India Office (Records: O.C. 1060). In it occurs the following entry: "1622, 17 Dec. Arvd at Saldania. Ther I mete the *Littell James* and to Hollandars bounde home." One of these Dutch ships was probably the *Leeuwin*, which left Batavia in company with the *Lesser James*.

There are traces of a third inscription at right angles to that of the *Lesser James*, but I have not yet been able to decipher anything which can give a clue to its history.

NOTES ON *ALOE SUCCOTRINA*, Lam.

By R. Marloth, Ph.D.

(Read June 28, 1905.)

On a previous occasion I drew attention to the fact that the real habitat of most South African succulents is not known or recorded, they having been introduced into European gardens one or two hundred years ago, and figured and described from cultivated plants.

One of the most striking examples of this kind is the species of Aloe called *Aloe succotrina*, because it was thought at the time that this plant furnished the drug which came from the island of Socotra. That error has been rectified since, for the plant which bears the name does not occur at Socotra, quite another one supplying the drug.

It was then surmised that the plant to which this name had been given by mistake, and which is still being cultivated at home under this name, might have come from South Africa, but as no botanist had ever recorded it from here, its origin remained a puzzle.

Some thirty years ago Dr. Bolus collected a plant in the Eastern Province, which Mr. Baker at Kew took at first to be the real *A. succotrina*, Lam., as figured by Commelinus * in 1697. Later on he recognised it to be *A. pluridens*, Haw. (Flor. Cap., vol. vi., p. 323); hence the true *A. succotrina* remained as unknown as before.

Unfortunately the matter has been complicated a little more in Dr. Schönland's paper referred to above. The author, not knowing the real *A. succotrina*, came to the conclusion that both names referred to the same plant, and he gives consequently the latter name as a synonym of the former. That is a mistake, for Baker's identification of Bolus's plant as *A. pluridens* is correct, and *A. succotrina* is quite different from it, as the fresh specimens and photographs of both species which I am exhibiting here will show. The foliage is quite different, for the leaves of *A. succotrina* are erect with a slight backward curve at the end only, while those of *A. pluridens* are quite recurved, almost hanging down. There are other points of difference of course, but they are not so easily noticed.

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* I am taking these statements from Dr. Schönland's paper "On some South African Species of Aloe," published in the Records of the Albany Museum, vol. i., p. 292, 1905.

The specimens of *A. pluridens* came from Zwartkops, near Port Elizabeth, and those of *A. succotrina* from the slopes of Table Mountain. It is rather surprising to find that the home of a plant of such conspicuous size and such special interest should have remained unknown for two centuries, although it grows in profusion a few miles outside of Cape Town. So far one spot only is known to me, which, however, is well hidden. It is situated about 1,200 feet above Newlands, on an immense field of boulders which must have been formed by the falling of an enormous cliff from the mountain above. There are hundreds, nay thousands, of boulders of all sizes, some as big as a house, with abysses between them that seem to lead into the interior of the earth. Where the spaces between the boulders have become filled with *débris* and leaf-mould, trees have succeeded in establishing themselves and are at present overshadowing some large groups of Aloes. These are doomed, for the trees must win in this struggle for existence. But where the boulders are freely exposed to air and light, where the aloes have been able to find a little soil in a crack or on a ledge, they have taken full possession of the place.

That no botanist or collector of the last century should have come across the plant is evidently due to the difficulty of access to the locality, for it is out of the track of the ordinary rambler. Only mountaineers who want to try the Window Gorge would pass it.

But it is a spot well worth visiting. The boulders alone are a sight, piled up and spread out over a field several acres in extent. Some portions are overgrown with bushes and trees, and their rotten trunks form dangerous bridges over some of the yawning spaces, but others are occupied by hundreds of these Aloes, adorned at this time of the year with tall spikes of red flowers.

In conclusion I may add that the only species of Aloe hitherto known from the Cape Peninsula, viz., *A. gracilis*, grows also at one spot only, which is not far from the station Glencairn on the Simonstown line. I look upon them as relics from a period of greater dryness than the present.

P.S.—A few days after the reading of the above notes, Mr. E. Dyke found a variety of *Aloe succotrina* among the rocks of the so-called Little Lionshead near Houtbay.

This locality is as much out of the way as the other one, for few people only will venture into the very rough ground and the cliffs which skirt the Little Lionshead on the seaward side.

It is also probable that a plant growing on rocks near the mouth of the Kleyn River is this species or its nearest ally *A. purpurascens*, Haw.

THE CLIMATE OF EAST LONDON, CAPE COLONY.

By J. R. Sutton, M.A., F.R.Met.S.

(Read October 25, 1905.)

This paper is a brief summary and discussion of the meteorological observations made at the West Bank, East London, during the 21 years 1884–1904, under the direction of the Harbour Board. My object in undertaking the work is chiefly to amplify the results obtained in some of my previous papers dealing with the meteorology of the table-land of South Africa.

Speaking generally, the material made use of here is not of the best—not nearly so good as that available for Kimberley (G. J. Lee), or for Durban. The observing hour seems to have been altered once or twice to one side or the other of 8 a.m., and also the manner of taking the readings. The observers have varied much in ability; and there is, unfortunately, considerable evidence that some of them regarded the work of reading the instruments as irksome, and did it in the most perfunctory manner. In computing the averages I have not hesitated to reject all the readings which show signs of negligence. Whole months, occasionally, defy explanation, and these have been rejected altogether. For instance, ten consecutive days are given below as a specimen of how meteorological observations ought not to be taken. It is an extract from one of the rejected months, giving the dry and wet bulbs at the hour of observation, the reading of the maximum and minimum air temperatures for the preceding 24 hours, and the readings of the maximum and minimum thermometers when reset at the hour of observation. The dates are purposely omitted:—

Hygrometer.		Preceding 24 Hours.		Reset.	
Dry Bulb.	Wet Bulb.	M.	*m.*	M.	*m.*
48°	44°	68°	42°	62°	47°
49	45	67	57	43	59
50	50	71	48	66	52
50	50	70	50	43	50
51	51	73	64	50	66
50	49	68	51	44	54
60	60	70	61	45	62
57	52	67	51	49	51
61	61	68	60	51	60
50	52	68	56	46	58

No information is given in the Register concerning the position or mounting of the instruments, or as to what corrections are necessary for index-error; and, indeed, it is not likely that such corrections would make any material improvement. For these reasons it is safer to consider the mean values given below as approximately comparable *inter se*, rather than as directly comparable with other registers. The following notes from the Inspection Reports of the Cape Meteorological Commission contain nearly all my information about the instruments:—

1883.—Fortin's Cistern Barometer, set of Thermometers, and a Rain Gauge, all in good order.

1884.—The Cistern Barometer at this station being found faulty, it was exchanged for the one belonging to the Port Office until a new one could be supplied. All the Thermometers and the Rain Gauge were in good order.

1886.—The instruments here were in good order.

1888.—The instruments at this station were all in good order. The exposure of the thermometer, however, in the Stevenson Screen was not good; it was too close to the ground, and in too confined a spot. I arranged for its removal to a more suitable place.

1891.—The instruments at East London are in and about the office of the Port Captain on the west or right bank [of the Buffalo River] . . . . I found the whole in good order and well kept, and the records neatly made up to date.

There is also a note in the Report for 1896 to the effect that the index error of the Barometer = + ·012 inch.

In addition to this, Mr. S. R. Pockley, the Secretary to the Harbour Board, informs me that "the distance of the thermometer screen from both sea and river is about 150 feet, and about 45 feet above mean sea-level. There has been no material alteration in the position of the instruments during the period January 1, 1884, to present date."

With regard to the dates, it should be remembered that the values of maximum and minimum temperature and rainfall are for the 24 hours ending 8 a.m. of the date of entry, the first and third not having been credited, as is usual in England, to the previous day.

The approximate monthly mean and extreme barometric pressures reduced to a temperature of 32° are given in the following Table, together with the total range observed in 21 years:—

	Means.	Maxima.	Minima.	Range.
	inches.	inches.	inches.	inch.
Jan. ……………	29·920	30·320	29·373	·947
Feb. ……………	·940	·302	·550	·752
Mar. ……………	·965	·390	·526	·864
April ……………	30·019	·508	·630	·878
May ……………	·056	·596	·335	1·261
June ……………	·127	·512	·664	·848
July ……………	·139	·648	·611	1·037
Aug. ……………	·102	·718	·551	1·167
Sept. ……………	·096	·616	·549	1·067
Oct. ……………	·031	·623	·462	1·161
Nov. ……………	29·973	·450	·427	1·023
Dec. ……………	·940	·377	·497	·880
Year ……………	30·026	30·718	29·335	1·383

The annual variation of pressure is of the same order as that obtaining at Durban and Kimberley, namely, greatest in July and least in January. It would appear, however, from the general run of these monthly means that the turning-points of the smoothed curve of pressure are a day or two later at East London than they are at Durban, just as those of Durban are a day or two later than they are at Kimberley. The range of monthly means from January to July is ·22 inch, or about ·02 inch less than the ranges at Durban and Kimberley, but practically the same as that of Philippolis and Aliwal North. It is therefore typical of the pressures of the low lands surrounding the South African table-land, and no doubt depends in some way (as in the case of Durban) upon the variation of maximum temperatures inland. The greatest pressure observed during the period under review was 30·718 inches, the least 29·335 inches, giving a total range of 1·383 inch. This is rather greater than the range found for Durban in the ten years 1888–97 (*i.e.*, 30·801 − 29·507 = 1·294 inch). The Durban observations, however, are made twice a day, at 9 a.m. and 3 p.m., while the East London observations are only made once, at 8 a.m. Were observations made at East London also at 3 p.m., we should expect still lower minimum pressures, and therefore it seems to follow that the total range at East London must be somewhat greater than that at Durban, while the actual mean pressure at the former place would be somewhere about a tenth of an inch the lesser. The greatest ranges of pressure are found in May, and in July–November, being nearly half as great again as those of the other months, including June. Exactly the same rule holds for Durban. It is during these months of greatest range of pressure on the coast that dust storms are most frequent over the central table-land.

The mean monthly maximum and minimum temperatures, and their arithmetic mean; also the greatest and least observed in any month, and the total range, are given below:—

	Mean Maxima.	Extreme Maxima.	Mean Minima.	Extreme Minima.	$\frac{M+m}{2}$	Range.
	°	°	°	°	°	°
Jan.......	75·6	97	64·3	52	70·0	45
Feb. ...	75·6	91	64·7	54	70·2	37
Mar. ...	74·6	101	62·6	51	68·6	50
April ...	73·1	106	59·2	47	66·1	59
May ...	71·5	94	53·7	42	62·6	52
June ...	71·4	91	50·3	39	60·9	52
July ...	69·5	93	49·2	36	59·3	57
Aug. ...	69·5	98	51·7	37	60·6	61
Sept. ...	69·1	98	54·5	43	61·8	55
Oct.......	70·1	98	56·9	43	63·5	55
Nov. ...	71·8	88	59·9	48	65·9	40
Dec. ...	74·6	94	62·7	47	68·6	47
Year ...	72·2	106	57·5	36	64·9	70

The curve of mean maximum reaches its highest value about the end of January, lagging a month behind the solstice; but its lowest value is more than two months later than the sun. The curve of mean minimum reaches its highest value during the first week of February, and its lowest during the first half of July. These epochs are probably largely determined by the differences of temperature between land and sea. There is a remarkable difference between the annual ranges of the curves of mean maximum and mean minimum: the mean maximum temperature of the winter months being only 6° or 7° lower than the mean maximum of the summer; whereas the mean minimum temperature has a range more than twice as great. This is in sharp contrast to the ranges over the central table-land, for at Kimberley, for example, the range of mean maximum is perhaps 30°, and that of mean minimum 24°. The small variation of the mean maximum temperature at East London throughout the year is largely due to the frequent hot winds of the winter months; while the night temperatures during the winter may be reduced more than they are in the summer by the land breeze. The highest shade temperature on record is 106°, the lowest 36°, giving a total range of 70°.

The high absolute maximum temperatures during the winter months are one of the most noteworthy features in the climate of the south and west coasts of South Africa. They generally come with a low barometer, and winds from some inland direction, and are excessively dry. Sparrman, who appears to have been perhaps the first to describe them, relates that "in the months of May, June, and July (which about the Cape elsewhere are the winter months, and are attended with copious rains) it is here quite dry, though frequently rather cool and bleak. The north-west wind at this time prevails here, as well as at the Cape; sometimes the wind veers about to the north, and brings with it the warmth of summer—a change which frequently occasions the milch-cows in Houtniquas to grow stiff in the joints. I was assured that it never rained when this north wind prevailed, probably on account of the chain of mountains, which, extending from east to west, proves a barrier to keep the clouds on the other side; or else by virtue of their attraction detains these condensed vapours on their summits." *

There was an exceptionally good observer at East London during a few months of 1886. He notes a maximum of 80° for the 24 hours ending 8 a.m., August 26th, and one of 92° in the following 24 hours, and makes the following remarks:—

(1) "Max. 80° is the actual temperature at the time of observation due to an exceedingly hot wind blowing. At no time during the previous 24 hours would the mercury have reached anything like this figure."

(2) "The cup of water on the wet-bulb thermometer was filled up at 8 a.m. when the observations were made, but on examination an hour after was found to be half empty, showing how great was the evaporation induced by the above-mentioned hot wind."

The same observer also remarks on the hot wind of September 11th, in which the temperature reached 98°: "Calm till 9 a.m. Hot wind from N. then set in, lasting all day, similar to that experienced on August 26th. This wind is an awful infliction while it lasts, as it feels red-hot."

These winds seem to be almost entirely confined to the hours of daylight. In no case do they seem to have very much effect upon the nocturnal temperatures, very seldom raising them more than 10°.

It has been stated that these hot winds last sometimes for several days; the "man in the street" affirms roundly that they last for a week. But such is not the case at East London, at any rate, although once or twice it has happened that there have been two

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* A. Sparrman, *A Voyage to the Cape of Good Hope*, Sec. Ed., 1786, vol. i., p. 281. Sparrman refers here to the country between Cape Town and what is now Port Elizabeth.

hot winds on two consecutive days, and now and then two in a week. For example :—

	m.	8 a.m.	M.
1889, April 11	65°	90°	106°
12	67	68	90
13	64	64	80
14	62	71	90
15	68	90	98
16	65	66	80

Here we see that although there were hot winds on the 11th, 12th, 14th, 15th, the mornings (as shown by the minimum temperatures) always opened cool. To the unobservant this would appear to have been a hot wind lasting a week. It should be mentioned that the high temperatures of the 11th and 12th are due to one barometric depression, those of the 14th and 15th to another.

At East London the seasonal distribution of hot winds is very pronounced, there being two maxima of frequency, one in the late spring and the other in the early autumn.* During the whole of summer and the middle of winter they are rare,† as will be seen from the Table below, giving the frequency expressed in the number of times observed in 21 years :—

	Above 90°.	20° above the Mean.		Above 90°.	20° above the Mean.
	No.	No.		No.	No.
Jan.	1	1	July	1	1
Feb.	1	...	Aug.	13	18
Mar.	2	1	Sept.	8	10
April	6	5	Oct.	3	4
May	9	7	Nov.	...	...
June	1	...	Dec.	2	...
			Total	47	47

In this matter of seasonal distribution they differ in a marked manner from the less frequent though fiercer hot winds of Durban, for at the latter place they are confined almost entirely to the spring and early summer. On the other hand, judging from the Reports of the Cape Meteorological Commission, they are more frequent in the winter on the west coast than they are (during the same season) on the south. Stewart gives the following monthly distribution of a total of 41 days upon which hot winds blew at Port Nolloth during 1900 * :—

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* Over the coast districts further west there is a similar semi-annual rainfall period.

† There are, however, frequently, in the winter, warm winds, say 15° above the mean of the month.

April	1	July	12
May	6	Aug.	8
June	11	Sept.	3

Their periodicities, therefore, probably depend mainly upon the annual movements of the permanent anticyclones of the southern hemisphere.

There seems to be no doubt that these hot winds originate on the table-land, albeit every northerly wind, even with a low barometer, is not necessarily a hot wind.† The following Table gives the average pressure and average maximum temperature conditions for the fifteen most strongly marked hot winds blowing at East London in the four years 1897–1900, for the seven days of which the middle day is the day of the hot wind, together with the corresponding synoptic elements for Kimberley and Durban. At East London itself the day of a hot wind generally opens with the wind somewhere about north-west, and not very much cloud; at the same time at Kimberley the wind is fairly strong between north and north-east and the sky clear; at Durban calms or north-east winds are the rule, and clear skies.

SYNOPTIC ELEMENTS DURING A HOT WIND AT EAST LONDON.

	Pressure.			Temperature.		
	East London.	Durban.	Kimberley.	East London.	Durban.	Kimberley.
	inches.	inches.	inches.	°	°	°
Third day before	30·149	30·248	26·264	68	78	75
Second day before	30·171	30·309	26·290	69	77	77
First day before	30·111	30·288	26·276	75	79	79
DAY..................	29·902	30·144	26·233	92	82	79
First day after ...	29·988	30·086	26·201	70	82	76
Second day after	30·095	30·219	26·219	70	78	76
Third day after...	30·125	30·296	26·231	69	79	78

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* C. Stewart, *Science in South Africa*, Art. "Meteorology," p. 40, 1905. The temperatures are not given.

† Sparrman was informed that on the Krombeek River, some distance east of Swellendam, "the west wind was the warmest; but what was very extraordinary was that the north wind was the coldest" (*Voyage*, vol. ii., p. 329).

Exactly as was found in the case of the hot winds of Durban,[*] so we find the temperatures and pressures of Kimberley well above the normal during the first half of the week, with a sudden fall to a lower temperature afterwards, and a gradual fall to a lower pressure. The variations of temperature and pressure at Durban are in the same direction as at East London, though they come rather later, and the variation of temperature is much less pronounced.

When the temperatures and pressures at East London and Durban on the day of a hot wind at the latter place are compared with the same elements on the day of a hot wind at the former, we find some very striking dissimilarities. Thus when the hot wind prevails at East London the barometer falls on an average during four days to the minimum ·247 inch at East London, and ·223 inch at Durban, the corresponding rises of temperature being 24° and 4° respectively; but when the hot wind is at Durban the barometer falls in the same period of time to the minimum ·356 inch at Durban and ·289 inch at East London, the corresponding rises of temperature being 24° at Durban and practically nothing at East London. That is to say, the depression which determines such a wind is actually deeper at East London when there is a hot wind at Durban than it is at East London itself when the hot wind is there. But there is this important distinction—that when the hot wind is at East London the direction there is about north-westerly (*i.e.*, from inland), whereas when the hot wind is at Durban the wind at East London is south-westerly (*i.e.*, up the coast).

SYNOPTIC ELEMENTS DURING A HOT WIND AT DURBAN, 1886–1904.

	Pressure.		**Temperature.**	
	Durban.	**East London.**	**Durban.**	**East London.**
	inches.	inches.	°	°
Third day before	30·151	30·029	80	71
Second day before	30·130	30·020	84	72
First day before	30·058	29·901	84	74
DAY	29·795	29·740	104	73
First day after	30·136	30·025	80	71
Second day after	30·131	30·087	81	72
Third day after	30·145	30·097	80	70

Taking into account, therefore, the synoptic conditions prevailing at Durban, East London, and Kimberley, while a hot wind is blowing at either of the former places, and the fact that the direction is always off-shore, there surely can be no reasonable doubt remaining that they are true Foehn winds, strongly resembling those of the lower slopes of the Alps described by Hann.[*] Nevertheless this is not to say that a South African hot wind is wholly explained. There seems to be a probability that some subsidiary process is involved in generating these high temperatures in addition to the adiabatic heating of a downcast current of air. We have seen that there are occasional temperatures during April of 90° at 8 a.m. at East London. Now the April mean temperature of the air at Queenstown, 100 miles north-west from East London, at 8 a.m., is 57°·6. If this air could flow at once to East London it would acquire a temperature, due to compression in falling 3,500 feet, of about 18°·7 more, making it 76°·3. We shall have, therefore, to account in some way for another 14° to get the observed temperatures. But air from inland must necessarily take time to reach the coast, so that Queenstown air would have to start some hours before 8 a.m. to get to East London at that time. If we assume that it starts before sunrise while at its mean minimum temperature of about 49°, it would acquire an additional 18°·7 in its descent and a small rise on account of diurnal temperature variation. This last would be less than it would have experienced if it had remained at Queenstown, because the coast variation is much less. It seems, then, that we have nearly 20° to account for if we assume the air to start from Queenstown at its normal temperature. Of course the temperature at Queenstown may be higher than usual to begin with, as it is at Kimberley at the same time; but it is not likely to be 20° above the normal. And if it were we should still have to account for it at Queenstown instead of at East London, and so only have shifted the incidence of our difficulty. At King William's Town, 30 miles from East London and 1,300 feet above the sea, the April mean temperature of the air at 8 a.m. is 63°·6. Adding 7° for adiabatic increase of temperature due to compression, and we have, as before, nearly 20° of rise still to explain, assuming the air to start from King William's Town at its normal temperature. Of course, if the rise of temperature is all adiabatic, then we must conclude that the air has started from higher levels, above the surface, say from an altitude of 7,000 feet at a temperature of about 53°. But it seems more likely that the friction of a dust-laden air may account for some, at any rate, of the 20° we want.

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[*] See J. R. Sutton, "Some Pressure and Temperature Results," &c., *Trans. S. A. Phil. Soc.*, vol. xi., part 4, p. 273.

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[*] See, *inter alia*, J. Hann, *Met. Zeit.*, January, 1904, p. 42. C. Stewart, *Science in South Africa*, p. 40. Also for comparison, Bartholomew's *Atlas of Meteorology*, p. 33 and Plate 32, 1899. J. Hann, *Lehrbuch der Met.*, p. 595, 1901. *Handbook of Climatology*, ch. xix., 1903.

The surface temperatures of the sea have been observed regularly at East London since 1897. They fall upon a curve very similar to that of the maximum temperatures of the air, with the same long-drawn-out minimum from July to September.[*] Monthly averages are :—

Jan.	67°	July	61°
Feb.	66	Aug.	61
Mar.	64	Sept.	61
April	64	Oct.	63
May	63	Nov.	65
June	62	Dec.	66
		Year	64

The rapid rise during the late spring and early summer is very marked. Hydrometer observations show a slight—very slight—increase in the density of the sea from July to September.

The cloud averages show two maxima in the course of the year, in February and in October, agreeing in this respect with Kimberley, and, in fact, with the greater part of the whole country lying between Natal and Pondoland on the east and Namaqualand on the west. The minima occur at the solstices. Neither of these turning-points show any special agreement with the monthly averages of rainfall, one reason possibly being that clouds of different types prevail at different seasons. Monthly averages are :—

	East London.	Kimberley.		East London.	Kimberley.
	8 a.m.	Mean.		8 a.m.	Mean.
Jan.	53%	40%	July	34%	17%
Feb.	56	42	Aug.	40	17
Mar.	50	35	Sept.	47	25
April	45	32	Oct.	56	31
May	39	21	Nov.	55	26
June	35	17	Dec.	52	37
			Year	47	28

In the East London Register the species of cloud does not appear, only the percentage of sky clouded, so that the relation between the clouds and the rain must be more or less conjectural; but if the conditions at Kimberley may be taken as a guide, there are maxima of clouds of a cirrus type in July and October, of a stratiform type in April and October, and of cumulus and allied species during the height of summer; and it is entirely due to the great increase in the two former in October that there is a general cloud maximum at that time.

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[*] *Cf.* C. Stewart, *Science in South Africa*, pp. 25, 48, 51.

Five years' observations of the direction from which the clouds are travelling have been made. Apparently they have been referred by the observers to magnetic North, and are read roughly to eight points. A rough correction to true North gives the following approximate Table of number of times the clouds have been observed moving from specified directions in five years:—

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
40	333	42	19	298	727	132	18

Some of these numbers doubtless include low-level driving mist. It will be seen that the prevailing cloud currents correspond to the directions of the prevailing winds (*i.e.*, N.E. and S.W.), excepting that the north-easterly cloud directions are relatively much less numerous than the same wind directions.* At Kimberley the prevailing cloud direction is very nearly west-north-west, four years' eye observations giving the following number of times seen:—

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
66	12	4	4	13	37	253	200

Thus neither at East London nor at Kimberley do clouds come to any extent from the south-east. Taken in conjunction with the fact that inshore winds are not frequent on the south-east coast of South Africa, these cloud directions furnish a strong argument against the "south-easterly rain-bearing winds" myth.†

The Table below gives particulars of the average monthly rainfall at the West Bank, East London, in the 21 years, 1884–1904, together with the greatest fall in one day, and the number of daily falls of assigned quantity :—

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* For these see J. R. Sutton, "The Winds of East London," *Q. J. R. Met. S.*, April, 1905.

† In occasional thunderstorms there are south-east winds. Sparrman mentions one during a hot spell of weather, which gave him a "headach," near the end of 1775. C. Stewart mentions an instance of a local thunderstorm at Port Elizabeth in which the wind was S.S.E. - S.

	Average.			Greatest Fall in one Day.	Number of Falls in 21 Years.		
	Monthly Fall.	No. of R. Days.	Fall per R. Day.		Less than 0·5 inch.	0·5 to 1·0 inch.	Greater than 1·0 inch.
	inches.	per month	inch.	inches.			
Jan..........	2·592	9·2	·275	2·07	166	16	11
Feb..........	2·206	9·3	·236	1·53	173	15	8
Mar.	2·288	9·2	·249	2·13	164	21	8
April	2·311	7·7	·301	3·15	131	21	9
May.........	1·653	5·0	·327	1·88	82	13	11
June	1·112	3·1	·359	2·77	50	8	7
July.........	·833	3·6	·230	2·10	68	5	3
Aug.	1·549	5·3	·293	3·09	93	13	5
Sept.	1·848	6·4	·287	1·90	109	18	8
Oct..........	2·266	9·4	·240	2·32	169	23	6
Nov.	2·452	9·3	·264	4·27	161	23	11
Dec.	2·153	7·7	·281	4·76	136	13	12
Year	23·263	85·2	·273	4·76	1,502	189	99

According to the Report of the Meteorological Commission for 1891, "the rain gauge is a permanent fixture on the ridge of the roof of the Port Captain's office, a tube leading from it down into his office," consequently, since the average velocity of the wind at East London is 20 miles an hour, we should expect the quantities of rain registered to be considerably too small. Fortunately "on the east side of the river, Mr. Padget, in the railway service, takes care of a rain gauge ; it is well placed on a good wooden stand in the yard of the maintenance department." A comparison between the annual quantities registered at the two places from 1883–1903, and published by the Meteorological Commission, shows great and varying differences between them, not only in the quantities but in the number of days reported. The average annual number of days of rain reported on the East Bank is 95, and only 77 on the West Bank. Only twice has the West Bank reported more days in the year than the other, and on two occasions it has reported only a few more than one-half. As for the annual totals, the West Bank fall varies from 55 per cent. to 90 per cent. of the East Bank totals. The averages for these 21 years are :—

	Inches.	Ratio.	Days.	Ratio.
East Bank.........	33·27	142	95	123
West Bank	23·42	100	77	100

In view of these differences it will be safer to regard the numbers in the previous Table as more or less approximate ratios.

The annual incidence of heavy rain is curious. It seems that in May and June more than 10 per cent. of the number of daily falls exceed an inch, whereas in October only 3 per cent. are so great. This confirms for East London what has previously been found for Kimberley, namely, that October differs in the character of its climate from all the other months.*

The Table below gives the direction of the wind, and of the cloud currents, immediately before and after rain in number of times observed, and for comparison the relative frequency of all winds :—

	Normal Wind Frequency.	Rain Wind.		Rain Cloud.	
		Beginning.	Ending.	Beginning.	Ending.
N.	19	8	11	4	8
N.E.	47	43	33	32	44
E.	9	2	6	1	4
S.E.	5	3	3	2	5
S.	16	5	7	22	28
S.W.	49	89	70	100	97
W.	39	49	69	25	15
N.W.	22	7	7	2	1

We see from this that while the normal frequency of south-west winds is 49 times out of 206, the frequency before rain begins increases to 89 times. In fact, rain simply elongates the normal mechanical resultant in a south-westerly direction. During rain there seems to be a tendency for the vane to shift slightly, pointing more landwards.

The Tables at the end give in twelve columns, for each day of the year, the following elements :—

1. The date.
2. The mean barometric pressure at 32°.
3. The greatest pressure observed in 21 years.
4. The least pressure observed in 21 years.
5. The mean maximum temperature in the shade for the 24 hours ending 8 a.m. of the opposite date.
6. The absolute maximum.
7. The mean minimum temperature in the shade.
8. The absolute minimum.

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* See J. R. Sutton, "An Introduction to the Study of South African Rainfall," *Trans. S. A. Phil. Soc.*, vol. xv., 1904.

9. The percentage of cloud.

10. The mean rainfall on the roof of the office of the Port Captain, for the 24 hours ending 8 a.m. of the opposite date.

11. The greatest fall in one day.

12. The number of times it has rained in 21 years on any given date.

One important point to be specially noted in these Tables is the spell of low pressure during the middle of July, and the following low maximum temperatures: the lowest mean maximum (and also the coldest day of the year) falling, just as it probably does everywhere else in South Africa, on July 17th.*

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* The lowest value of mean daily maximum temperature—*i.e.*, 64°—appears opposite July 18th, and belongs, as explained in the text, to the 24 hours ending 8 a.m., July 18th. The *hottest* day at Greenwich is July 15th.

Jan.	P	MP	*m*P	M	M′	*m*	*m*′	C	R	R′	R
	inches.	inches.	inches.	o	o	o	o	%	inches	inches	days.
1	29·941	30·169	29·631	75	85	63	56	47	·96	·85	3
2	·920	·143	·748	75	82	64	58	43	·24	·11	3
3	·894	·072	·569	77	84	65	57	54	·41	·12	5
4	·854	·205	·626	76	84	66	59	68	1·07	·73	5
5	·895	·086	·699	76	87	64	59	70	2·37	·47	10
6	·973	·207	·733	75	81	62	55	47	1·70	1·01	9
7	·964	·198	·787	75	84	63	55	38	1·40	·40	8
8	·909	·098	·656	74	84	64	56	47	1·37	·67	4
9	·867	·108	·717	76	85	63	56	54	2·32	·69	9
10	·877	·227	·465	75	81	63	56	54	1·36	·70	7
11	·941	·195	·716	76	81	65	58	55	1·48	·79	4
12	·878	·123	·669	75	83	64	56	45	·56	·44	3
13	·934	·138	·797	77	97	64	59	57	1·98	1·04	6
14	·894	·104	·716	75	85	65	60	56	1·06	·45	4
15	·912	·127	·576	75	80	65	55	58	1·54	·54	7
16	·884	·165	·441	77	85	65	56	52	·87	·59	4
17	·888	·146	·748	76	88	64	58	55	5·44	1·53	10
18	·930	·121	·698	76	81	63	56	47	2·44	1·36	6
19	·910	·169	·560	74	83	64	61	50	1·82	1·35	6
20	·932	·240	·684	75	80	64	57	62	·54	·34	5
21	·910	·135	·700	76	86	66	61	55	·68	·24	4
22	·934	·137	·718	76	88	66	60	53	·62	·23	4
23	·959	·211	·654	76	86	64	57	53	1·81	·67	8
24	·891	·207	·521	75	80	65	58	53	2·30	·76	8
25	·900	·157	·373	75	84	64	55	60	3·69	2·07	8
26	·916	·236	·687	77	87	65	52	61	3·14	1·20	8
27	·898	·320	·670	76	89	64	56	53	1·63	1·00	6
28	·900	·258	·622	77	80	65	59	56	1·22	·35	9
29	·935	·125	·702	76	81	65	54	54	2·90	1·67	6
30	·918	·183	·738	75	80	65	58	52	2·40	1·60	7
31	·949	·161	·734	76	89	64	54	45	1·78	1·10	7

Feb.	P	MP	*m*P	M	M′	*m*	*m*′	C	R	R′	R
	inches.	inches.	inches.	o	o	o	o	%	inches.	inches.	days.
1	29·976	30·216	29·660	75	83	63	54	48	1·10	·46	6
2	·944	·154	·769	76	82	65	60	57	·79	·35	4
3	·947	·127	·714	75	90	65	58	61	1·27	·73	7
4	·950	·111	·722	76	90	65	57	60	·56	·46	3
5	·904	·097	·704	76	89	65	60	61	·46	·22	3
6	·906	·094	·688	76	90	65	55	50	2·33	1·18	7
7	·938	·231	·628	76	86	64	56	70	2·80	·62	8
8	·943	·181	·626	76	89	64	58	51	3·28	1·32	9
9	·974	·238	·775	76	88	64	54	45	1·66	·63	8
10	·931	·159	·705	76	89	64	56	40	·85	·23	7
11	·903	·209	·575	76	91	64	60	37	·22	·09	4
12	·911	·156	·579	77	87	65	60	59	1·54	1·08	4
13	·918	·135	·710	75	79	64	57	56	1·06	·35	6
14	·950	·150	·765	75	80	65	55	64	1·03	·38	8
15	·958	·143	·683	77	83	65	56	50	2·61	1·30	8
16	·965	·161	·804	75	83	66	61	47	·86	·47	6
17	·923	·195	·550	76	84	66	60	57	1·40	·41	9
18	·898	·110	·636	76	88	65	60	61	·23	·20	2
19	·880	·266	·665	76	83	65	58	58	1·94	1·04	7
20	·913	·177	·714	76	84	65	59	56	·78	·24	6
21	·962	·283	·700	76	82	64	55	74	2·58	1·03	10
22	·966	·163	·627	75	82	64	59	44	1·79	·80	10
23	·962	·196	·776	75	81	65	60	66	·62	·27	6
24	·998	·250	·703	75	81	66	59	64	2·82	1·47	7
25	·984	·215	·731	76	87	65	60	73	4·54	1·53	12
26	30·011	·181	·852	74	82	65	61	60	3·10	·69	11
27	29·958	·302	·626	74	80	64	60	50	2·40	·70	10
28	·915	·228	·750	74	83	65	59	50	·56	·20	5
29*	·870	29·896	·828	76	82	65	63	57	1·15	·75	3

* Four Leap Years.

Mar.	P	MP	*m*P	M	M′	*m*	*m*′	C	R	R′	R
	inches.	inches.	inches.	°	°	°	°	%	inches.	inches.	days.
1	29·907	30·099	29·634	77	84	65	60	61	1·25	·54	7
2	·985	·228	·759	76	90	64	57	61	2·54	·98	6
3	30·032	·390	·768	76	82	63	56	50	·48	·22	6
4	29·986	.266	·757	74	78	63	58	45	·21	·18	3
5	·957	·132	·720	74	78	63	57	33	·49	·17	6
6	·979	·370	·704	75	80	64	57	63	·83	·67	4
7	·942	·287	·679	75	81	65	60	52	2·02	·90	9
8	·924	·270	·690	75	83	64	56	58	·55	·23	7
9	30·005	·275	·740	75	81	63	54	50	·82	·48	5
10	29·950	·244	·567	74	81	63	55	37	·62	·33	5
11	·967	·277	·702	75	84	63	55	55	1·11	·58	3
12	·964	·333	·676	77	84	64	56	46	·13	·04	4
13	·940	·283	·738	75	82	64	57	57	1·11	·30	7
14	·969	·173	·740	75	84	64	54	70	3·82	2·00	7
15	·964	·284	·737	73	79	62	56	50	3·87	2·13	9
16	·992	.240	·593	74	88	62	55	46	1·42	·35	7
17	·971	·213	·730	75	81	62	55	45	1·13	·42	6
18	·977	·157	·801	75	80	62	56	36	·62	·31	4
19	·969	·225	·645	74	81	63	54	52	1·15	·47	8
20	·958	·160	·737	73	79	62	54	70	3·62	1·20	9
21	·982	·332	·715	73	82	62	54	48	3·24	1·57	9
22	·983	·304	·802	74	77	61	53	51	3·64	1·75	9
23	·949	·243	·527	74	80	62	57	48	1·69	·55	7
24	·959	·325	·676	75	94	62	51	56	1·59	·51	10
25	·988	·246	·526	74	81	61	54	48	2·07	1·21	6
26	·959	·225	·716	75	101	61	54	38	1·36	·72	3
27	·949	·176	·664	75	79	62	52	39	1·37	·64	5
28	·951	·185	·735	74	79	62	59	60	·99	·46	5
29	·931	·313	·824	74	78	61	53	47	1·94	·74	8
30	·956	·273	·707	73	77	60	54	37	1·18	·43	7
31	·991	·309	·715	74	81	61	52	37	1·18	1·08	2

April.	P	MP	*m*P	M	M′	*m*	*m*′	C	R	R′	R
	inches.	inches.	inches.	°	°	°	°	%	inches.	inches.	days.
1	29·994	30·243	29·689	74	83	62	54	35	·56	·32	4
2	30·051	·390	·632	75	91	62	52	56	4·48	1·80	7
3	·043	·367	·816	73	79	59	50	41	5·78	3·15	7
4	·021	·320	·810	74	82	60	51	26	·39	·28	5
5	29·965	·207	·745	74	79	60	53	45	1·16	1·02	3
6	·961	·283	·768	74	88	61	53	46	1·65	·62	6
7	·988	·366	·680	73	83	61	53	55	3·43	2·17	6
8	30·015	·287	·774	72	84	60	55	38	1·02	·31	7
9	29·956	·232	·743	72	79	61	53	41	·86	·57	3
10	·984	·243	·670	73	79	61	55	50	·79	·32	4
11	·986	·325	·737	74	89	61	52	60	1·66	1·48	5
12	·981	·282	·770	75	106	60	50	56	2·31	·70	9
13	30·007	·231	·772	74	90	60	49	45	2·27	2·05	3
14	·041	·273	·818	75	95	59	52	42	1·58	·58	5
15	·022	·508	·630	74	90	61	51	39	1·05	·66	4
16	·007	·285	·681	75	98	61	52	62	·62	·30	6
17	·071	·309	·856	73	88	60	54	56	1·59	·63	9
18	·014	·301	·776	75	89	60	53	55	·58	·14	7
19	·023	·295	·824	72	78	59	54	38	1·05	·38	6
20	·045	·367	·776	72	78	59	53	51	2·47	·96	8
21	·026	·334	·801	72	81	57	51	37	1·20	·53	5
22	29·979	·429	·745	71	79	57	49	37	1·11	·39	5
23	·958	·214	·667	72	83	59	50	35	·99	·76	4
24	30·005	·453	·714	73	82	58	51	42	·47	·31	5
25	·049	·256	·698	73	89	58	47	37	·26	·20	4
26	·025	·230	·760	73	84	56	49	43	1·23	·73	5
27	·113	·306	·762	74	97	56	50	42	·84	·39	5
28	·095	·284	·809	71	78	55	48	41	2·00	1·16	5
29	·082	·345	·767	72	87	56	49	46	3·51	1·85	5
30	·065	·282	·825	72	79	57	52	41	1·63	·70	4

May.	P	MP	*m*P	M	M'	*m*	*m'*	C	R	R'	R
	inches.	inches.	inches.	o	o	o	o	%	inches.	inches.	days.
1	30·019	30·346	29·886	72	79	57	51	41	·40	·20	6
2	·021	·200	·659	73	81	57	50	40	2·03	1·88	4
3	·070	·427	·783	72	83	57	50	57	2·18	1·60	4
4	·054	·317	·699	71	79	57	48	42	2·24	1·42	5
5	·008	·213	·732	73	92	56	47	31	·20	·20	1
6	·029	·295	·702	72	92	56	48	43	·77	·50	2
7	·013	·261	·698	71	93	55	43	45	·64	·26	5
8	·047	·453	·804	71	83	55	48	45	1·02	·44	5
9	·078	·428	·765	73	89	55	43	47	2·23	1·45	6
10	·055	·360	·616	71	76	53	44	20	·88	·60	4
11	·028	·227	·813	72	93	54	47	49	·03	·03	1
12	·038	·311	·682	72	80	53	43	34	·74	·51	3
13	·037	·325	·516	74	93	54	48	34	·93	·83	3
14	·071	·381	·693	70	82	54	45	50	2·10	1·25	3
15	·000	·386	·754	70	86	55	48	40	2·00	1·02	4
16	·008	·415	·689	73	88	55	50	52	4·24	1·25	6
17	·064	·494	·778	72	94	56	47	52	·83	·30	6
18	·055	·414	·760	71	77	53	48	42	·64	·52	2
19	·086	·446	·786	71	80	53	44	31	·25	·25	1
20	·135	·401	·821	70	80	52	43	33	1·82	·77	4
21	·097	·393	·605	71	84	51	43	26	·08	·08	1
22	·044	·337	·609	70	83	52	45	27	·35	·21	2
23	·011	·305	·643	73	91	54	45	35	1·22	1·15	2
24	·007	·177	·756	74	92	53	42	32	·17	·08	3
25	·060	·340	·753	73	86	52	45	44	1·11	·92	3
26	·016	·506	·335	70	89	52	45	40	1·22	·62	4
27	·060	·361	·761	70	86	52	43	58	2·36	1·72	5
28	·153	·375	·576	71	84	50	45	33	1·07	·35	6
29	·138	·596	·661	69	80	50	44	34	·67	·44	4
30	·124	·461	·643	71	85	51	45	26	...	...	...
31	·106	·423	·811	72	84	50	44	30	·33	·33	1

June.	P	MP	*m*P	M	M'	*m*	*m'*	C	R	R'	R
	inches.	inches.	inches.	o	o	o	o	%	inches.	inches.	days.
1	30·083	30·478	29·664	74	89	51	42	27	...	...	...
2	·067	·444	·809	70	85	51	45	31	·11	·08	2
3	·129	·512	·709	73	90	51	43	41	1·42	·66	4
4	·114	·454	·859	70	82	50	46	23	·02	·02	1
5	·059	·315	·817	72	89	50	41	25	·19	·15	2
6	·110	·375	·839	75	91	52	45	43	...	...	...
7	·125	·390	·839	72	88	51	39	24	·05	·05	1
8	·127	·411	·803	71	86	51	42	32	2·31	2·15	2
9	·211	·501	·808	71	88	52	44	59	2·74	1·27	4
10	·163	·489	·786	69	88	50	45	40	4·35	2·77	5
11	·112	·417	·700	69	83	49	41	33	1·43	1·25	3
12	·114	·458	·857	72	87	50	40	48	1·42	·84	3
13	·110	·452	·750	70	85	48	42	22	1·34	1·04	4
14	·116	·473	·703	72	87	49	41	30	·08	·06	2
15	·147	·416	·908	71	82	49	42	33	·07	·07	1
16	·137	·334	·931	71	85	49	43	24	·04	·04	1
17	·101	·453	·809	70	85	50	41	35	·73	·45	3
18	·166	·486	·852	73	89	50	43	37	1·34	1·05	3
19	·147	·385	·796	70	87	51	40	32	·11	·07	2
20	·094	·320	·842	72	86	50	41	31	·15	·15	1
21	·093	·412	·886	72	84	51	44	37	·13	·13	1
22	·121	·475	·762	72	84	51	44	42	·14	·14	1
23	·104	·367	·754	72	87	50	41	31	·34	·31	2
24	·113	·397	·754	73	90	50	43	41	·61	·58	2
25	·155	·482	·875	72	84	50	44	33	·14	·14	1
26	·145	·442	·883	73	88	50	41	58	·40	·19	3
27	·154	·482	·819	72	88	52	43	41	1·46	·69	5
28	·139	·427	·672	70	76	50	43	28	·55	·50	2
29	·164	·490	·930	69	81	50	46	37	·36	·20	2
30	·197	·403	30·006	71	87	50	41	30	1·32	1·28	2

July.	P	MP	mP	M	M′	m	m′	C	R	R′	R
	inches.	inches.	inches.	o	o	o	o	%	inches.	inches.	days.
1	30·191	30·388	29·907	70	81	49	43	30	.07	·04	3
2	·140	·340	·952	69	80	49	37	40	·55	·21	4
3	·140	·339	·897	70	81	48	40	24	3·16	2·10	3
4	·151	·464	·809	71	82	50	44	40	...	...	...
5	·148	·527	·879	71	88	50	45	36	...	...	...
6	·149	·538	·878	70	80	49	43	30	·13+	·13+	1
7	·115	·413	·805	71	82	48	39	23	·85	·85	1
8	·127	·343	·671	71	84	48	40	22	·21	·21	1
9	·133	·360	·822	69	83	48	41	28	...	...	...
10	·136	·353	·813	69	80	48	40	33	·58+	·28+	3
11	·182	·502	·882	69	81	48	42	34	·17	·17	1
12	·134	·423	·694	67	86	49	39	27	·30	·24	3
13	·080	·379	·869	71	86	51	43	30	1·75	1·55	4
14	·053	·380	·750	72	88	53	45	52	1·14	1·10	2
15	·067	·364	·856	73	86	49	41	33	·15	·09	3
16	·084	·333	·611	70	86	49	41	43	...	...	...
17	·181	·470	·962	68	86	48	44	48	1·12	·28	8
18	·219	·566	·991	64	71	49	40	39	·97	·42	5
19	·183	·648	·725	66	73	48	40	32	1·05	·64	3
20	·194	·522	·810	69	87	48	43	25	·23	·23	1
21	·144	·378	·793	69	81	47	41	32	·58	·44	2
22	·080	·366	·772	70	86	51	44	33	·02	·02	1
23	·116	·374	·633	71	93	51	41	34	·15	·15	1
24	·135	·489	·735	68	75	50	41	43	·11	·06	3
25	·200	·510	·931	69	87	49	43	33	·29	·12	4
26	·211	·485	·879	68	78	49	42	39	·62	·46	2
27	·184	·541	·778	68	85	50	43	32	·80	·60	4
28	·127	·452	·733	69	88	50	36	35	·92	·49	3
29	·081	·374	·800	70	87	50	41	38	·33	·18	4
30	·091	·449	·769	71	88	51	44	43	·08	·06	2
31	·134	·556	·842	71	82	49	40	25	1·16	·60	4

Aug.	P	MP	mP	M	M′	m	m′	C	R	R′	R
	inches.	inches.	inches.	o	o	o	o	%	inches.	inches.	days.
1	30·105	30·410	29·834	70	82	50	42	33	·46	·31	3
2	·140	·406	·881	68	75	50	44	38	1·09	·88	8
3	·119	·398	·819	68	72	49	40	29	·22	·12	2
4	·056	·307	·780	71	85	51	41	33	·56	·33	2
5	·137	·650	·809	71	87	53	46	46	·06	·06	1
6	·149	·718	·821	69	91	52	44	34	1·23	·76	7
7	·104	·550	·695	70	98	52	45	37	1·67	1·00	5
8	·136	·411	·854	69	92	51	40	25	·17	·12	2
9	·089	·257	·885	68	78	51	43	43	1·78	1·10	4
10	·113	·422	·864	68	76	51	44	36	3·72	3·09	4
11	·042	·371	·571	71	90	51	41	34	·12	·12	1
12	·104	·386	·672	69	94	51	47	42	·35	·17	8
13	·099	·468	·657	69	80	50	41	40	·64	·32	8
14	·151	·422	·551	69	92	52	43	48	·61	·40	8
15	·072	·357	·721	68	90	50	43	20	·85	·54	4
16	·050	·244	·608	70	92	52	42	35	·76	·70	2
17	·160	·508	·818	70	87	51	44	58	·28	·15	8
18	·149	·436	·919	68	94	51	43	42	1·14	·41	6
19	·115	·480	·828	68	91	51	43	47	1·85	1·67	3
20	·134	·474	·855	69	89	51	42	52	1·67	·64	4
21	·117	·424	·790	69	89	51	44	25	·75	·41	4
22	·110	·421	·787	70	85	51	44	41	·90	·60	4
23	·040	·438	·696	72	96	54	44	40	2·24	1·86	5
24	·106	·409	·830	74	90	53	42	51	·65	·31	4
25	·105	·405	·755	68	75	54	42	46	1·59	·62	7
26	·043	·528	·558	72	90	54	37	53	1·56	1·00	5
27	·081	·502	·571	70	92	53	45	47	·48	·31	8
28	·098	·470	·852	71	94	53	43	50	1·22	·48	4
29	·064	·386	·745	68	74	53	43	33	·20	·12	2
30	·068	·593	·837	69	76	53	43	45	2·55	1·76	6
31	·111	·463	·818	69	76	53	45	45	1·15	·75	2

Sept.	P	MP	*m*P	M	M′	*m*	*m*′	C	R	R′	R
	inches.	inches.	inches.	°	°	°	°	%	inches.	inches.	days.
1	30·182	30·440	29·931	69	95	52	45	40	1·71	·76	3
2	·252	·588	·773	69	92	52	45	45	1·49	·93	6
3	·164	·535	·653	68	85	53	43	50	1·92	1·08	5
4	·092	·515	·827	69	94	54	44	47	2·39	1·75	7
5	·153	·535	·833	70	92	55	49	45	·02	·02	1
6	·137	·402	·750	69	93	53	44	44	·71	·29	4
7	·070	·324	·809	67	73	54	45	44	·78	·38	3
8	·042	·586	·697	70	78	53	44	36	1·12	·60	4
9	·087	·369	·863	70	89	53	48	56	1·50	·70	7
10	·111	·550	·828	67	72	52	44	54	5·58	1·90	7
11	·143	·616	·833	67	92	52	45	48	2·57	1·12	7
12	·093	·418	·700	69	98	53	46	45	·79	·58	4
13	·093	·403	·759	67	72	53	43	47	·30	·22	3
14	·176	·503	·852	68	73	52	43	48	1·75	1·02	4
15	·155	·447	·800	67	86	53	46	42	·91	·37	6
16	·072	·492	·664	71	94	54	44	46	1·08	·50	4
17	·109	·363	·762	69	83	54	44	47	·92	·37	3
18	·137	·381	·870	70	90	55	44	38	1·15	·83	4
19	·097	·370	·772	69	78	56	47	47	1·07	·75	6
20	·066	·401	·760	69	79	57	48	49	1·09	·62	3
21	·038	·413	·620	70	85	56	49	44	·28	·15	3
22	·040	·296	·585	69	76	56	51	49	·73	·42	3
23	·023	·323	·549	69	75	56	48	52	1·00	·53	4
24	·082	·284	·770	71	79	55	48	44	1·21	·62	5
25	·081	·360	·819	70	75	56	50	60	1·09	·54	6
26	·046	·433	·734	69	78	57	53	64	2·67	1·31	7
27	·094	·385	·754	70	78	56	45	48	1·15	·62	6
28	·011	·243	·647	70	78	56	50	33	·31	·30	2
29	·013	·336	·612	71	78	58	47	40	·85	·50	4
30	·016	·264	·658	70	78	58	50	59	·66	·42	4

Oct.	P	MP	*m*P	M	M′	*m*	*m*′	C	R	R′	R
	inches.	inches.	inches.	°	°	°	°	%	inches.	inches.	days.
1	30·020	30·303	29·783	70	76	58	49	48	1·11	·53	4
2	·041	·338	·764	69	74	56	47	47	·64	·25	5
3	·081	·564	·696	69	77	55	45	58	2·07	·95	5
4	·077	·538	·801	69	77	54	43	61	1·32	·75	6
5	·020	·623	·615	70	93	56	46	61	2·85	1·55	4
6	·038	·344	·462	72	98	57	48	52	·78	·27	6
7	·081	·413	·623	71	93	57	49	62	1·06	·36	8
8	·042	·489	·709	69	78	56	45	58	5·41	2·32	9
9	·057	·473	·770	70	82	56	45	46	2·66	1·10	8
10	·036	·425	·768	69	76	56	44	45	·73	·67	3
11	29·996	·342	·752	71	76	57	46	50	2·04	·67	6
12	30·011	·383	·700	70	85	57	48	76	·87	·31	5
13	·086	·403	·697	69	74	57	48	63	1·80	·47	8
14	·045	·374	·637	68	75	56	49	54	1·52	·75	4
15	·120	·389	·869	70	77	56	47	64	1·30	·30	7
16	·080	·392	·678	70	79	58	49	60	1·29	·87	7
17	29·978	·304	·684	70	77	58	47	53	1·41	·97	3
18	30·029	·293	·800	71	77	58	50	55	·88	·25	9
19	·006	·290	·690	71	80	58	49	58	·50	·19	4
20	·045	·327	·835	70	74	58	49	68	1·18	·20	10
21	·038	·304	·781	70	79	57	47	57	2·10	·49	13
22	29·991	·407	·737	69	76	57	49	48	1·48	·51	8
23	30·049	·511	·642	70	78	56	48	53	·99	·40	6
24	·005	·481	·614	71	79	57	49	59	·46	·14	5
25	·070	·415	·727	71	78	57	49	55	1·26	·40	8
26	·019	·491	·724	70	74	56	42	58	1·74	·86	7
27	29·971	·302	·745	70	77	59	47	61	1·25	·58	7
28	·916	·213	·547	71	82	60	52	51	1·27	·60	6
29	·993	·195	·784	72	90	58	48	43	3·21	1·40	8
30	30·006	·330	·714	71	77	57	51	55	·65	·59	3
31	·007	·239	·647	71	80	57	50	47	1·77	1·02	6

Nov.	P	MP	*m*P	M	M′	*m*	*m*′	C	R	R′	R
	inches.	inches.	inches.	o	o	o	o	%	inches.	inches.	days.
1	30·020	30·385	29·732	70	79	57	50	60	1·93	·83	3
2	29·906	·241	·715	70	74	59	50	52	·60	·25	5
3	·984	·287	·694	72	83	59	55	73	1·49	·55	4
4	·989	·354	·600	70	76	59	50	50	1·20	·47	8
5	30·007	·229	·749	71	78	56	48	48	·99	·47	4
6	29·990	·257	.679	71	78	59	51	63	1·97	1·01	6
7	·996	·291	·802	72	77	59	51	63	2·79	1·13	9
8	30·032	·450	·744	71	75	59	52	52	2·88	1·23	9
9	29·979	·414	·736	71	77	59	49	49	1·39	1·14	5
10	·930	·085	·630	72	77	59	52	38	·45	·37	4
11	·944	·111	·684	72	81	60	55	57	·60	·19	7
12	·994	·364	·765	72	82	60	50	57	·46	·19	5
13	30·001	·360	·702	72	83	61	53	66	2·55	1·09	12
14	29·986	·284	·662	70	75	59	51	52	3·91	1·25	7
15	·993	·201	·702	71	82	60	53	50	5·36	4·27	6
16	30·015	·310	·770	73	82	61	52	44	·86	·42	6
17	29·935	·264	·649	73	81	61	54	61	1·53	·87	5
18	·972	·188	·661	72	80	60	52	55	3·05	1·65	6
19	·954	·240	·695	71	76	61	53	69	3·61	·81	9
20	·957	·230	·427	71	76	60	55	46	2·22	·80	8
21	.939	·306	·612	72	75	59	51	41	1·31	·63	7
22	30·009	·235	·797	73	81	60	51	50	2·04	1·30	5
23	29·989	·286	·670	72	78	61	55	55	1·50	·62	8
24	·976	·201	·678	72	78	62	55	57	1·62	·80	8
25	·942	·180	·735	72	88	62	54	53	·85	·25	7
26	·970	·213	·773	73	77	61	54	55	·82	·29	9
27	·955	·278	·768	72	78	61	53	61	1·96	1·12	8
28	·938	·349	·734	73	84	61	54	44	·47	·26	4
29	·948	·130	·531	74	85	61	54	39	·05	·03	2
30	·940	·339	·541	74	78	62	55	68	2·03	·75	9

Dec.	P	MP	*m*P	M	M′	*m*	*m*′	C	R	R′	R
	inches.	inches.	inches.	o	o	o	o	%	inches.	inches.	days.
1	29·944	30·256	29·695	72	78	62	52	61	·58	·28	7
2	·939	·153	·590	73	84	63	53	55	1·04	·57	5
3	·964	·214	·677	74	86	62	50	48	·77	·35	5
4	·980	·310	·700	73	78	61	55	46	·66	·36	5
5	·935	·211	·628	73	80	61	53	46	1·19	·58	4
6	·898	·094	·681	74	84	62	56	37	·32	·14	5
7	·946	·176	·497	76	94	62	56	50	1·71	1·15	7
8	·968	·171	·735	76	94	62	56	45	·32	·23	3
9	·915	·247	·618	75	85	63	56	42	2·04	1·09	6
10	·968	·211	·637	75	80	62	56	57	1·43	1·17	4
11	·936	·307	·624	73	79	63	55	53	·36	·14	5
12	·960	·302	·621	74	81	62	55	50	1·45	1·03	5
13	·932	·211	·696	74	80	63	54	56	1·59	·75	5
14	·988	·316	·639	74	84	63	47	58	1·77	1·75	2
15	·929	·353	·498	74	83	63	53	42	2·42	1·40	5
16	·938	·377	·521	75	85	63	55	51	·39	·22	4
17	·958	·241	·615	75	81	64	55	51	·28	·24	3
18	·881	·151	·524	75	88	64	55	41	·42	·18	5
19	·911	·091	·702	74	81	64	55	79	3·68	1·38	6
20	·907	·226	·505	74	86	63	54	78	6·32	4·76	8
21	·949	·224	·672	75	90	62	55	56	2·90	·83	8
22	·913	·164	·659	74	81	62	57	42	·52	·32	3
23	·938	·200	·734	75	83	63	57	42	·36	·18	4
24	·992	·289	·829	75	87	63	57	55	1·85	1·06	6
25	·954	·182	·797	74	85	62	55	41	·89	·50	3
26	·939	·139	·725	75	89	63	55	52	·46	·23	3
27	·934	·101	·730	75	83	64	53	47	1·93	·83	6
28	·912	·124	·623	75	84	64	57	47	1·48	·60	6
29	·889	·160	·624	76	85	64	60	58	1·65	1·17	4
30	·966	·357	·679	75	80	63	59	64	2·31	·42	13
31	.998	·354	·767	74	86	63	56	64	2·13	1·05	6

THE CYCLE YEAR 1905 AND THE COMING SEASON.

By D. E. Hutchins, F.R.Met.Soc.

(Read November 29, 1905.)

The year 1905 is an important one to those who are interested in long-period weather forecasts. The year 1905 is the calculated maximum of sunspots, and, so far as one can judge by the sun's present appearance, it is likely to be the year of actual maximum sunspots. The year 1905 is a maximum rainfall year according to another of my Cape cycle years, namely, the 12·5-year cycle, which, in compliment to Dr. Meldrum (one of the first investigators in this field of inquiry), I have named Meldrum's cycle. And Broekner's 35-year cycle comes also into operation, as I shall explain later. We have thus as regards the year 1905 and the coming season three cycles favourable to good seasons. I propose now to glance briefly at each of these cycles, and then to consider what may be their effect on the coming season.

Sunspot or Solar Cycle of 11·11 *Years.*

The solar cycle has a mean period of 11·11 years. Sunspots have been observed to have a period which is sometimes so much more than 11 years, and sometimes so much less, that occasionally we have a maximum getting into the place of a minimum, or *vice versâ*. This has occurred twice since sunspots have been under observation, but other solar phenomena, such as faculæ and terrestrial phenomena, which are directly dependent upon the solar cycle, show less variation than the sunspots as observed. For the purposes of my forecasts, prepared in 1888, I have adhered to the mean period of 11·11 years, and the rains which are reasonably referable to the solar period, it will be seen from the cyclical diagram on the wall, have not varied more than a year from the 11·11 period. Thus, in 1850 the sunspot rains were punctual at the sunspot maximum; in 1861 these rains came a year late; in 1872 they were punctual; in 1883 they were punctual; in 1895 they came a year late. The next sunspot or, to speak more correctly, solar period brings us to 1905—the present year—and this seems likely to be the maximum year of observed sunspots. For some months the sun has been rarely free from spots, several visible without any magnifying power. Yesterday an ordinary field-glass showed four spots ranged in a long line in the sun's southern hemisphere.

In connection with sunspot rains there is a feature which I have referred to in some of the cyclical diagrams as "Lag" rains. The cyclical diagrams on the wall for Grahamstown and Durban show "Lag" rains in 1874 at Durban, and at Grahamstown in 1874 and 1886. On some of the other long-period rainfall records these "Lag" rains are more in evidence. On the Maritzburg-Gardens-cliff cyclical diagram they are in evidence in 1864 (one year late), in 1874, and (weakly) in 1896. They will be found discussed in my "Cycles of Drought and Good Seasons," published in 1888. They are not noticeable in recent years, and as the record extends it may be found necessary to abandon them as unproven. Some of them may be connected with sunspots as observed. But I am inclined to attach little importance to observed sunspots. I have in all my work confined myself to the solar cycle of 11·11 years, and that this is the correct view to take appears to be borne out in the diagrams before you. In 1870 occurred the strongest maximum of sunspots observed in that century. During that year and the preceding year and the following year there was drought in South Africa. The solar maximum, according to the 11·11 period, fell in 1872, and with it came good rains east and west in South Africa. As Sir Norman Lockyer observes (*Nature*, July 15, 1905), sunspots are only one and a very partial expression of solar energy.

Meldrum's Cycle of 12 *and* 13 *Years alternating.*

In my work, "Cycles of Drought and Good Seasons in South Africa," referred to above, this will be found described at page 104 as "the Mitigation Drought of the sunspot minimum," since they first appeared in the guise of a break in droughts which were connected with the sunspot minimum. Further research led me to modify this view, and to regard these rains as of equal importance with the other two cycles of Cape rainfall. Sir Norman Lockyer and Dr. Lockyer, of the Solar Physics Observatory, Kensington, have shown that good rains in India occur at periods of maximum and minimum sunspots; and Sir John Eliot, and I subsequently (*Nature*, February 9, 1905), have shown that there has during the last 10 years been a connection between good rains in India and good rains in South Africa, so that the mitigation rains in my early work resolve themselves into light rains at the sun spotminimum and heavy cycle rains at intervals of 12 and 13 years alternating. This cycle of 12 and 13 years alternating (or 12½ years as a mean period) I termed Meldrum's cycle, at the conclusion of my work in 1888, as a compliment to Meldrum, the eminent Mauritius astronomer, who was the first to connect in an unmistakable manner solar activity with terrestrial meteorological phenomena. As early as 1876 Meldrum's view was accepted that there was an unmistakable connection between the frequency of sunspots and hurricanes in the Indian Ocean. If Meldrum's cycle continues as it promises, it will be pleasant in this way to perpetuate Meldrum's name. In 1892 the 12·5-year cycle brought almost the heaviest rains ever experienced to the Cape Peninsula and the south-west. We are concerned with it to-night, since it is again before us in 1905.

Brückner's Cycle of 35 Years.

Brückner, as you are aware, has made extensive researches which tend to show that a large class of terrestrial meteorological phenomena recur at a period of about 35 years. Brückner's 35-year cycle has been confirmed and extended by the researches of J. Hann and by the results of Richter's study on the variations in the Swiss glaciers. Brückner's discovery arose out of a study of the varying levels of the Caspian Sea, which, being a closed inland sea, furnishes an index of the variations of rainfall over the wide area draining into the Caspian Sea—an area extending north even above Moscow. (Russel has followed a similar line of inquiry with regard to Lake George, in New South Wales, and by and by data from the African lakes will be precious.)

Brückner published some of his most important results in 1890. This year these results have found their way into the daily press with reference to the fierce criticism that has been raised over ordinary short-period weather forecasting and long-period forecasting. It has been claimed by the admirers of Brückner in the public press that his researches would enable us to predict the characters of seasons in a practical way, which would be an immense advantage to the world at large. This, I need not say, is a result which has not yet been arrived at. Brückner's researches, widespreading and important though they are, lack that element of precision which is seen in the Cape weather cycles. I am mentioning Brückner's cycle this evening because, although his maximum rain period has been fixed about 1878, 1879, or 1880, and thus should not recur till somewhere about 1914, yet it is part of the Lockyer cyclical work to connect Brückner's cycle with a major cycle of sunspots. Now, 1870 was the big sunspot maximum of the century, and 1870 plus 35 will bring us to 1905, our present year. To repeat, then, although 1905 is not Brückner's year of maximum rainfall, the Lockyer discovery makes it a particularly important year of maximum sunspots.

South African rainfall records are too short to afford much scope for studying the influence of Brückner's cycle on South African rainfall. The Royal Observatory has rainfall records for 64 years, and Maritzburg-Gardenscliff, in Natal, for 51 years. These show no tendency for rainfall to recur in 35 years; but two very dry years at the Royal Observatory are separated by 35 years, and two droughts in Natal recur at 35 years. It is too soon yet to say whether this correspondence is accidental.

The "Storm" Cycle of 9 *and* 10 *Years alternating.*

Two years ahead lies the most powerful of the three Cape weather cycles—the so-called "Storm cycle." This I propose to discuss next year. It is for practical purposes the same as Russel's 19-year Australian weather cycle. This cycle has also cropped up in other countries. It is noteworthy that 19 years is the period of revolution of the moon's nodes.

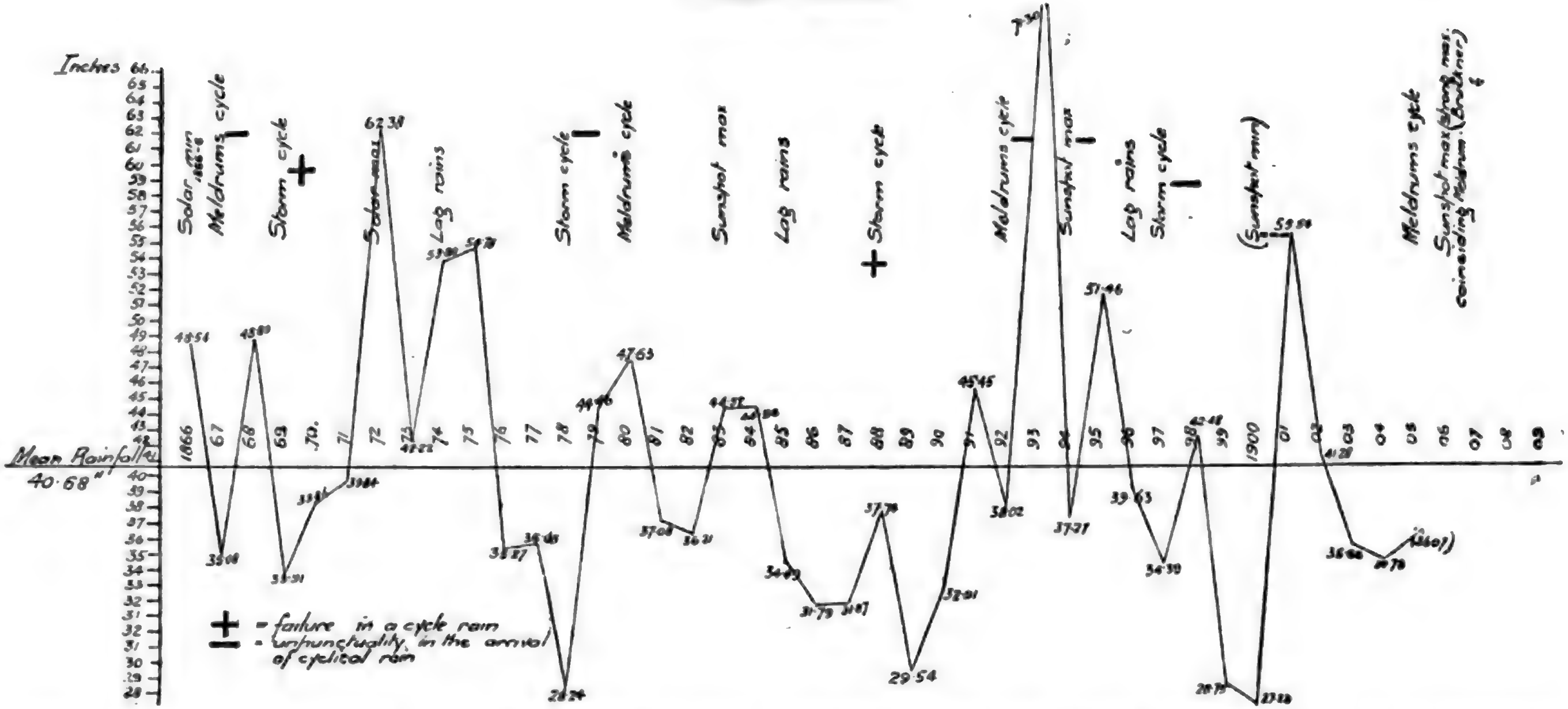
Cyclical Diagrams.

With this explanation of the three Cape weather cycles I will now proceed to call your attention to the cyclical diagrams on the wall. I have selected these out of a much larger number in my possession to which, it will be understood, I refer in the course of the following remarks. The diagrams selected, namely, Royal Observatory, Cape Town: Grahamstown: and Durban: have been chosen on account of the length and reliability of their records. The first point that will strike you on looking at these cyclical diagrams is the wonderful regularity with which South African rains fit into these three weather cycles. I know of no other country in the world where the rainfall shows the same regularity.

For the light, though precious, rains of the interior districts less dependence can be placed on cyclical regularity. To a large extent the cyclical rains are masked by irregular and by local rains. But I have seen no South African rainfall where the indications of cyclical influence could not be traced.

Brückner's world-wide researches show a reversal phase for inland

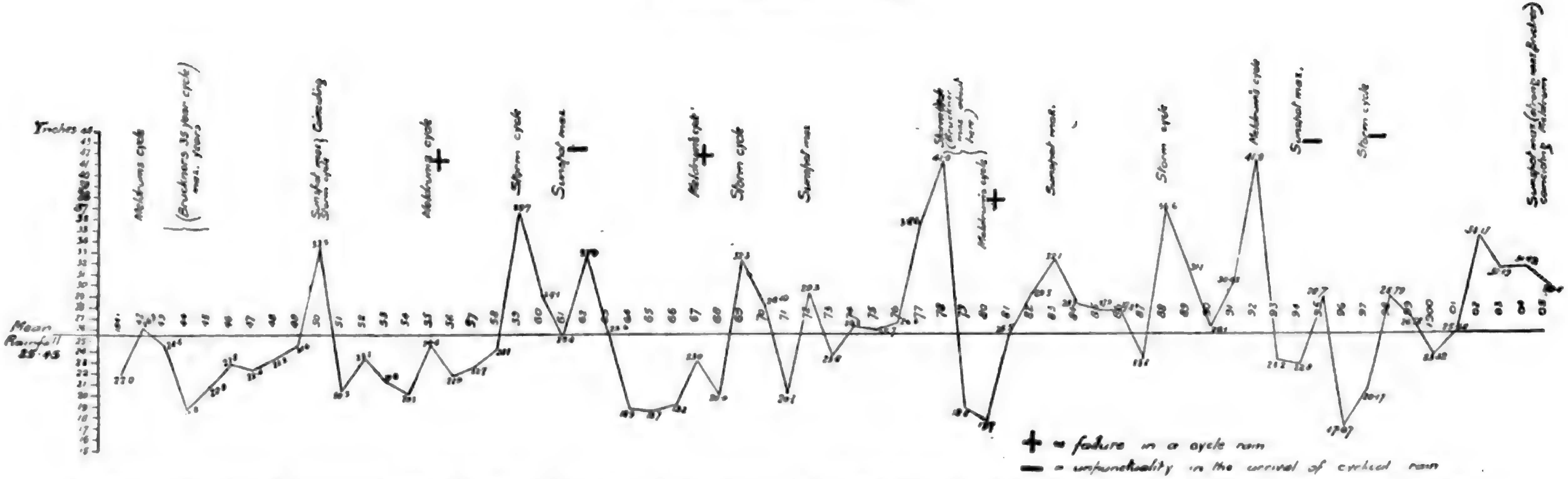
DURBAN—NATAL.



Note :—The "Storm" cycle usually fails at eastern stations to bring rain, and here it has failed twice out of four times. With this exception, and the "Lag" rains, the total irregularity at Durban amounts to two failures and five unpunctualities of one year each.

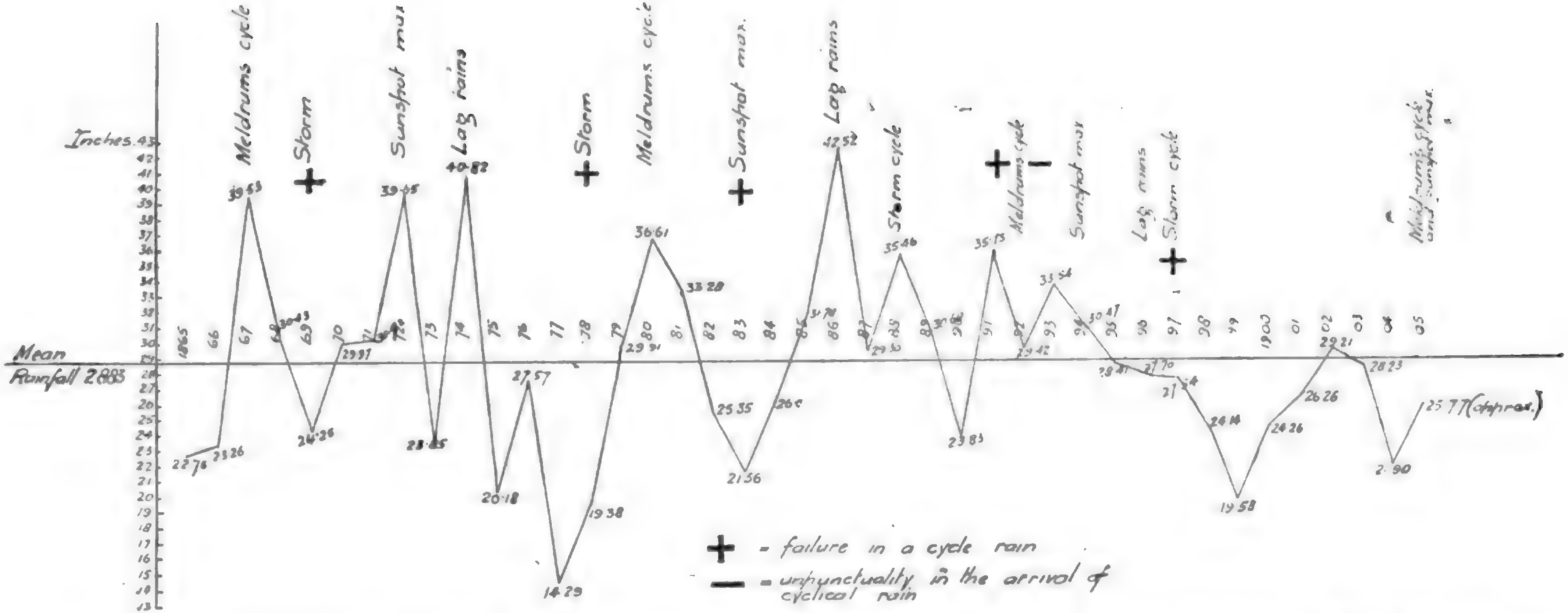
Note :—Instead of Sun-spot read Solar.

ROYAL OBSERVATORY.



Note:—Apart from the irregular 1902 and 1908 rains there is but one case of failure and two of weakness—all in Meldrum's cycle. There are three unpunctualities, each one year late.

GRAHAMSTOWN.



Note:—The "Storm" cycle usually fails at eastern stations to bring rain, and here it has failed three times out of four. With this exception, and the "Lag" rains, the total irregularity at GRAHAMSTOWN amounts to one failure (1883) and one unpunctuality (1892), and one rain without cycle in 1891.

stations, viz., wet periods near the coast correspond to dry periods inland, and *vice versâ.* This, too, is often noticeable in Australian droughts.

A second interesting point to note in these cyclical diagrams is how far the rainfall predicted in 1888, when they were drawn up, has corresponded with the predictions then made. In 1888 I drew these cyclical diagrams, fitting them into the three Cape weather cycles, and contending that the cycles were not going to change because we had mapped them, that they would proceed in the future as they had in the past, and thus afford us a fair indication of the probable character of the rainfall of each season. How far these predictions have been fulfilled you now see. The red marks on these diagrams show where there has been irregularity or unpunctuality. I shall now offer a few remarks regarding each rainfall period that has occurred since 1888, taking them in the order of their occurrence.

FORECAST AND RESULT.

Meldrum's Cycle Rainfall in 1892.

This in my 1888 work was noted as mainly an eastern cycle. The first three maxima on the Royal Observatory diagram all agreed in bringing only a small rainfall; the fourth maximum brought no rainfall, but the first maximum after 1888 brought the heavy rainfall of 1892. Here, then, we had, as it were, a cycle improving on its forecast!

In the east of Cape Colony and Natal the 1892 Meldrum cycle rains ran over three years, some stations having the heaviest rainfall in 1891, and others in 1893. These differences are partly due to the records being kept in calendar instead of seasonal years. The Natal inland districts (Maritzburg) had good rains on all three years; most of the Cape eastern stations had a break of the rains in 1892 (note particularly Evelyn Valley). Durban had the highest rains on its records in 1893, and Umtata and Queenstown the highest rains in their records in 1891. I will ask you to carefully note on the Durban cyclical diagram the phenomenal rains of 1893. In that year Durban had 71 inches of rain, against an average of 41. This, then, was Meldrum's cycle at its last appearance. It showed itself unmistakably right through the coastal districts from the Cape Peninsula to Maritzburg, and it showed itself as strong in the west as it had done previously in the east of Cape Colony. The inland districts of Cape Colony showed its influence faintly and irregularly, as is usually the case with their irregular rainfalls. The northern colonies show the same remarkably heavy rainfalls, *but a year, or perhaps two, sooner* (the records from these stations are not in calendar years). There have been nothing like such rains since either at Johannesburg or Bulawayo. We know now that as regards 1905 this cycle has *not* come in a pronounced form a year sooner at the northern stations; but we must not forget the interference of the two cycles this year—1905.

The Solar Cycle Rains of 1894.

Looking at the Royal Observatory cyclical diagram, you will see that the solar maximum rains of 1894 came weak and a year late in 1895. The weakness on the Royal Observatory diagram is local. At Ceres, the other end of the axis of heavy western rainfall, the rainfall for 1895 was 57½, against an average of 39 inches. At eastern stations the solar maximum rains of 1894 failed or came a year late. The rains failed at many eastern stations in Cape Colony; there were pronounced rains in Natal, but a year late, viz., in 1895. At all stations in Cape Colony where these solar rains were felt they came a year late. At northern stations, Johannesburg and Bulawayo, the solar rains were well developed and punctual, and, like the Meldrum cycle rains mentioned above, they came *a year before* the Cape rains.

"Lag" solar rains can be seen for certain nowhere. This is perhaps due to the interference of the more powerful "Storm" cycle. As we have seen, these "Lag" rains have on certain previous occasions been strongly marked, so that their failure, owing perhaps to the interference of the Storm cycle in 1897, is notable.

The Storm Cycle Rains of 1897.

There were some violent storms in 1897. (In July of that year a railway train was blown over bodily as it stood in a siding between Woodstock and Salt River, near Cape Town.) But the rainfall was late and weak. It was weak at most stations, and a year late at all stations in Cape Colony and the Natal coast. As on every previous occasion for the last 65 years, it brought no rain to Maritzburg. At the northern stations, Johannesburg and Bulawayo, it was punctual, coming *again about a year sooner* than in the south.

The Irregular Rains of 1902, 1903, *in the South-west.*

I am not here this evening to undertake special pleading on behalf of the three Cape weather cycles, and I freely admit that these rains in the south-west came as a surprise to me. If you run the eye over the whole of the rainfall registered at the Royal Observatory back as far as the year 1841, it will be seen at a glance that there is nothing nearly so abnormal as the rains of 1902 and 1903. I predicted rains about then, connected with the sunspot minimum, but I did not think these rains would extend to the south-west. In the event they went right through South Africa, from Cape Town to Salisbury in Rhodesia; and, like all the other cycle rains, they began in the north first. In the Cape Peninsula and Malmesbury they began in 1902 and lasted till 1904; but this duration was local. At Ceres, the inland side of the axis of heavy rainfall in the south-west, they had less than three-fourths the average rainfall in 1903. Going eastward, we see irregular distribution at once in the incidence of this abnormal rain. Grahamstown and King William's Town had practically none of it. At the two neighbouring high-level stations Evelyn Valley had tremendous rains in 1903, while Katberg had none. Again Aliwal got simply a drought mitigation in 1902; Aliwal and Queenstown moderate rains in 1901.

A possible explanation occurs to me with regard to the abnormal 1902 rains. They may be due to the delayed and irregular sunspot minimum. The sunspot minimum was due in 1900, and at Salisbury, the most northern station, heavy rains set in in 1899, and continued until 1901, while at Bulawayo the rains were slightly above the average in 1901 and 1902. Coming further south to Johannesburg, we find well-developed rains in 1901 and 1902; and further south to Natal, we find that Durban had heavy rains in 1901, while Maritzburg shared the 1902 rains of the west of Cape Colony. We thus see a chain of irregular rains extending from north southwards, and it seems possible to regard these as in some way connected with the irregular sunspot minimum of those years.

In 1901 came the extraordinary summer rains in the south-west of Cape Colony; in January of that year 5 inches of rain were registered at the Royal Observatory. And these abnormal rains extended to New Zealand, but not to Australia.

Nevertheless except for the small south-west area of winter rains, the irregular rains of 1901–1902 were correctly forecasted. Page 109 of "Cycles of Drought and Good Seasons," published in 1888, reads, "1889, 1900, 1901, 1902, 1903, all years of drought, with an irregular mitigation of one or two years, good or average rainfall, *occurring most probably about* 1901."

In the Annual Report of the Meteorological Commission for 1902 is one of those interesting graphical diagrams which the Secretary to the Meteorological Commission contrives to give us, from time to time, out of his slender resources. In this diagram is shown the monthly incidence of the 1902 rainfall. This diagram shows us exactly during what months and over what areas the irregular 1902 rains fell. In the Cape Peninsula they culminated in June and September. The heavy June rain of Cape Town was absent in the south-west generally, but the September rains ran through the whole of the southern and western coast districts. In the summer rainfall areas of South Africa the rains came during spring and autumn, except in Kaffraria, where there was rain in June. But the most instructive part of the diagram is the "abnormality" one. This shows that the abnormal rains throughout South Africa occurred almost entirely in June and September. In July there was a drop to normal rainfall. There was abnormal drought during spring and autumn, and slight drought during July.

The same diagram published with the Meteorological Commission Report for 1903 shows that the excessive rain occurred in June in the south-west and in November on the southern coast. Though the rainfall amounted to 94 inches on Table Mountain (St. Michael's), the general character of the year in Cape Colony was "an exceptionally severe drought lasting throughout the year," the year's mean for all Cape stations being 19 per cent. below the normal (Report of Meteorological Commission for 1903).

The real significance of these 1902 and 1903 irregular rains will be seen when it is considered that the effect of them and of the unusually heavy last Meldrum cycle rains (1892) has been to raise the mean rainfall of the Royal Observatory by nearly ½ inch. Up to 1888 the mean rainfall at the Royal Observatory was 25·43 inches. It is now 25·9 inches.

CONCLUSIONS.

In view of the more ample material that has accumulated since 1888 the following conclusions seem justified:—

1. The three main weather cycles are of general application throughout South Africa. I had considered in 1888 that the Storm cycle brought practically no rain to the eastern stations, and Meldrum's cycle little or no rain to western stations. The experience of the last 17 years shows that both may extend east and west beyond their area of greatest influence.

2. Observations from the northern stations are as yet too short to draw safe conclusions, but they seem to indicate that the pulse of heavier rainfall occurs a season earlier at northern stations (Transvaal and Rhodesia).

3. There are obscure indications of a tendency to rain at the sunspot minimum, and possibly the irregular rain of 1902 may be accounted for as a sunspot minimum rain. It so happens that the normal sunspot minimum periods (11—22—33—44—55·5—67—78—89—100 in each century) have since the year 1841 so frequently coincided with other cycles that the exact influence of the sunspot minimum is difficult to trace. In the long chain of the Royal Observatory rainfall figures the sunspot minimum has had no practical influence till we get to the doubtful case of the 1902 rains. At other stations sunspot minimum rains are more clearly traceable. Note the rains of 1866 at Durban, of 1900 at Bulawayo, Salisbury, and Johannesburg. Further observations are necessary before it can be stated what is the exact influence of the sunspot minimum on South African weather.

4. Up to the present the direct influence of Brückner's 35-year cycle is inappreciable in South African weather.

FORECAST FOR THE ENSUING YEAR.

As on previous occasions, this forecast is based (1) on the cyclical indications, and (2) on such information as is obtainable of the weather prevailing in neighbouring areas. In the light of what has been said above the present cyclical position will, I hope, be clearly understood. 1905 is a double-cycle year; that is to say, the solar cycle and Meldrum's cycle coincide. In my forecasts, published in 1888, the following appears against the year 1905: "Most probably general good rains. There is no precedent in meteorological records for these two cycles coinciding." For 1906 appears the entry: "Probably good rains with drought at a few stations." The rains so far in 1905 have been heavy at intervals and marked by violent storms —witness the storm at Durban and those in the Cape Peninsula at about the time when a large portion of the town of Malmesbury was destroyed by a storm; but the total of the 1905 rains has been moderate in the Cape Peninsula and also in the north. In the Cape Peninsula we may regard the 1905 rains as practically finished, and assume a total of 29·5 inches. This is less than 4 inches above the average. From the north, where the summer rains have already decidedly set in, I have the following data:—

From Zomba it is reported that good rains have set in for the last two months, and with the exception of strong, fitful easterly winds, the season is normal.

In Rhodesia the rains during September and October have been less than usual, with consequently higher temperatures. Wind velocity normal.

So far this season in the Transvaal has been drier at most stations than last year, but there has been more rain at Pretoria, though less at Johannesburg. At Pilgrim's Rest and other eastern stations there has been so far considerably less rain this spring than last spring.

Lake Chrissie, in one of the wettest parts of the eastern Transvaal, affords a practical illustration of the effects of the recent droughts. The case is mentioned in a report just issued by the Transvaal Meteorological Department. "There is a legend among the Boers of the district that if ever Lake Chrissie dried up the Dutch people would lose their independence. During the latter part of the war the lake was perfectly dry for the first time during the memory of man." I visited Lake Chrissie towards the end of the winter of 1903. It was then a noble sheet of water, but, I was informed, shallower than in the old times. In 1904 Lake Chrissie dried up, and it has been dry again this last winter of 1905.

Rains in the Nile Basin.

The Director-General of the Survey Department, Cairo, writing under date, November 8, 1905, states that this year's Nile flood has been markedly below the average. The rains both in Abyssinia and in the equatorial Nile regions were weak and late. "At the end of the rainy season there was a general improvement, but still the Abyssinian rains of September and October did not reach the average." There was also some sign of improvement in the rains over the equatorial lakes and Northern Uganda as the rains retired southward. The Director-General summarises this season's rains thus:—

"The rains of 1905 in the Nile basin were very late and weak; little improvement occurred during the season, giving a flood considerably below the average; some late improvement may have taken place in the extreme southern parts of the basin, but this is uncertain."

The Indian Monsoon.

The Indian Monsoon, except in Burmah, Bengal, Assam, and Bihar, has been a bad one, and the country was only saved from famine by a timely burst of rainfall at the end of September. In the Burmah-Bihar area the average excess was 12·5 per cent. above the normal. Elsewhere—that is to say over the greater portion of

India—there was an average deficiency of 33 per cent. below the normal. (Dr. G. T. Walker, Meteorological Report to Government of India.)

On the whole, the indications from India are similar to those from Abyssinia and the Nile basin; that is to say, the rains were weak and late in beginning, but showed an improvement at the finish. So that as regards South Africa, the Indian Monsoon does not afford an indication more definite than that of the Nile and Abyssinia. It is worthy of note that the failure of the Indian Monsoon was on the western side; that is to say, that which is nearest to South Africa.

Forecast: Summer Rainfall Area, South Africa generally, except the Southern and South-west Coast of Cape Colony.

The year 1906 coming between two rainfall periods, there may be short and local droughts, or the rains may run on to the heavy rainfall period which is ahead of us in 1907, and probably 1908. The outlook now is several years of good rainfall ahead.

Forecast: South Coast and South-west.

Strong south-easters (really southerly and south-westerly winds) may be expected during the summer.

The cyclical indication for next winter's rains is that they will be moderate.

A word of warning may be added in conclusion. Long-period forecasts cannot in the nature of things have anything like the precision attached to the short day-or-two forecasts, which are framed simply on a study of the approaching weather movements. It is perhaps unfortunate that the word "forecast" has been applied at all to long-period weather predictions. In any case, it is advisable to remember that the latter are at best but a calculation of probabilities, and an indication of what may be expected to affect the coming season as a whole.

Thus, farmers may expect general good seasons for the next two or three years, but this is not to say that there will not be drought in certain places; and, as I have mentioned, for the drier inland districts the rains are too irregular for the cyclical forecast to have any practical value. After 1908 there are six years of drought to look forward to, with an irregular mitigation of the drought, most probably about 1911 or 1912.

UNDERGROUND WATER IN SOUTH-EASTERN BECHUANALAND.*

By Alex. L. du Toit, B.A., F.G.S.

(Read February 28, 1906.)

In almost every part of South Africa the question of water supply is of the utmost importance, and the area known as Bechuanaland is by no means an exception.

Nowhere are there any perennial streams, and in comparatively few spots are there facilities for storage of flood-water, that is by individual effort, unless with great difficulty and at great expense; furthermore, springs and fountains are by no means as numerous as in the area south of the Orange River.

As a necessary consequence, if we except the case of storage of rain-water, the supplies are obtained principally from wells and, to a lesser degree, from boreholes. The number of the latter is increasing but slowly, for many reasons have prevented the more extensive utilisation of drills.

The volume of water obtainable from these artificial openings, even in cases where the pumping is effected by wind-power, is strictly limited, and irrigation on any scale is quite impossible.

In the following the author will endeavour, firstly, to point out the considerable influence of the geological formation on the storage of underground water; and secondly, will consider the potentialities of such a supply. In this paper the term South-eastern Bechuanaland will be taken to include the fiscal divisions of Mafeking and Vryburg as far to the west as Kuruman. Doubtless much will be applicable to the areas adjoining.

Natural features.—The area consists of a rather flat, or but slightly undulating, country of rather monotonous aspect.

Around the town of Vryburg the altitude is generally close on 4,000 feet above sea-level, but northwards there is a gentle rise of

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* *Communicated with the permission of the Geological Commission.*

from 300 to 600 feet towards the boundary dividing Vryburg from Mafeking, and this constitutes the watershed. Beyond this, both to the north and north-west, we find a gently rolling country with a gradual fall towards the Kalahari.

On the south drainage is effected by the Dry Harts River, while on the north are various tributaries of the Molopo, namely, the Mosita, Setlagoli, and Maretsani Rivers, and the Ramathlabama Spruit. To the west are the Mashowing and Kuruman Rivers.

In the east there is comparatively little vegetation, most of the timber having been cut down for use in the Kimberley mines or destroyed by bush-fires, but west of the railway, and at a distance of from 20 to 30 miles from it, the country is usually covered with large thorn trees, while the ground is thickly grassed.

The existence of such an abundant vegetation in a district where surface-water is usually absent invariably impresses the traveller with amazement.

Geology.—Over almost the entire division of Mafeking, and westwards through Genesa, the basement rock is granite and gneiss, but exposures are not frequent on account of the considerable depth of reddish-yellow sandy soil produced by their disintegration. To the north and north-east of Vryburg, and again at Mafeking, are extensive flats formed by diabases and amygdaloidal rocks, these being later than the granite and having a considerable development in the adjoining portions of the Transvaal.

At Vryburg is the north-easterly termination of the Campbell Rand limestone and dolomite—a formation that constitutes the immense Kaap Plateau. It stretches westwards as far as Kuruman, and then turns northwards, passing in a broad belt through Morokwen towards the Molopo River and the Bechuanaland Protectorate.

At Vryburg and further south, in the Dry Harts River valley, there are depressions in the older rocks, that have been filled in with shales and boulder-clay belonging to the Dwyka formation.

Subsoil water.—Rain falls in the summer-time principally, and commonly in the form of thunder-showers.

The Dry Harts River runs during a portion of the year, but north of the watershed the rivers only come down after continued thunderstorms. The flow is, however, soon lost in the sand of the river-beds, and in the Molopo, below its junction with the Setlagoli River, running water is seldom found.

By digging shallow pits in the beds of the rivers the natives obtain water; curiously enough, water appears to be absent in certain reaches and is found again at points further down the valleys. Why this should be so is not evident; possibly the water may make its way beneath one or other of the banks either along an old and now-buried channel or along cracks and fissures in the rocks.

According to Penning,* a somewhat analogous phenomenon exists in the lower portion of the Molopo River north-westward from Kuruman; his notes on the underground water of this part of the Kalahari, and also of the region still further to the west, afford very considerable and interesting information.

A rather curious feature, confined to the granite area, is the occurrence of what are known as "sand-wells." By sinking a pit in the sand a little water collects at the bottom; on deepening the excavation the water-level does not remain stationary, but falls considerably, and the supply is soon exhausted. These "sand-wells," curiously enough, are often productive at points quite high up on the sides of granitic ridges.

Ground water.—From the soil the seepage gradually makes its way downwards into the underlying rock, and the depth to which the water will penetrate will depend upon the nature of the rock, its porosity, degree of decomposition, the existence of joints, &c.

In addition there is the slow but regular movement of the ground water towards those parts of the country having a lesser elevation. In this the movement is aided by fissures, channels, or "veins" of varying width, along which the water can more readily travel than through the pores of the rock. Though it is an open question whether these "veins," which make water-boring in many cases so uncertain an operation, can be located by human agency, there are, nevertheless, various surface indications that may influence a person in making a selection of a site.

(1) *Topography.*—It is usual, of course, to choose a site at as low a level as will be convenient, yet sometimes, paradoxical as it might appear, this may not be the best situation. For example, supposing we have the common case of a wide flat crossed by a deepish river-valley, it is not unusual to find that a well sunk near the centre of the flat will give a better supply, and that also at a shallower depth, than will be obtained at points on the slope not far from the river-bed. This is due to the rapid fall of the water-table towards the line of drainage below the river channel.

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* W. H. Penning, "Gold and Diamonds," chapters iv. and v., London, 1901.

As far as possible ridges and watersheds should be avoided, for the area that can be drained by a well in such a position is invariably small, and the proportion of rainfall absorbed by the soil is much lower than on the flats. A troublesome strip of country is the main watershed, and the wells along it are considerably deeper than elsewhere. The normal scarcity of water is intensified by the existence of a belt of compact quartz-porphyry.

(2) *Dykes, faults*, &c.—It is not uncommon to find shrubs clustered thickly together along a certain line with such regularity as to produce a narrow belt resembling an artificial plantation. These "aars," as the Dutch farmers call them, may extend in straight lines for miles, and are due to several causes.

Basic igneous dykes may give rise to these phenomena, and in most cases wells sunk on their outcrops give good supplies of water. The effect may be produced by quartz-reefs, but they are not very plentiful here, and the underground circulation of water is therefore not appreciably influenced by them.

Sometimes, on sinking, no foreign rock is met with, but there is a zone of crushed and decomposed material along which the water makes its way; this is not unusual in the granite area.

In the dolomite region such "aars" form narrow ridges a few feet higher than the surrounding country; they are generally capped with calcareous tufa, and support a thicker vegetation than round about.

(3) *Calcareous tufa.*—Patches of soil are very frequently found covered by a deposit of calcareous tufa of greater or less thickness. In many cases this points to the presence of water at no great depth.

In the dolomite area, and again in that occupied by diabase and amygdaloid, the carbonate of lime is derived by direct solution from the former rock, and by the decomposition of the minerals in the latter. Moisture containing the carbonate in solution is drawn up to the surface by capillary forces, and by evaporation the tufa is formed. In many cases the rims and floors of pans are composed of a similar deposit.

Sometimes, however, the carbonate of lime is brought down by rivers which take their rise in a dolomite area, and the tufa so formed is deposited upon any kind of rock, and may therefore be no indicator of underground water.

(4) *Pans and vleys.*—These depressions are extremely numerous throughout the district, and vary from a few yards to over a mile in diameter; they exist on nearly every formation.

These pans hold water for a certain period during the rainy season; all of them dry up during the winter.

Experience has shown that a well sunk within or upon the edge of a pan usually gives a good supply of water at a shallow depth. The reasons for this are threefold: firstly, the underlying rock, being kept moist, tends in consequence to decompose and become more porous; secondly, as the level of the pan is often at quite an appreciable depth below the surrounding country, moisture gravitates towards the depression; and thirdly, owing to seepage from the pan itself, the level of the water-table beneath and immediately around the pan is usually higher than elsewhere.

For abundance of supply it would be difficult to beat the little depression on the farm Water Pan between Vryburg and Genesa; the underlying rock consists of a very decomposed and highly porous granite.

Brak pans, which are so characteristic of that portion of the Kalahari north of Upington, are practically unrepresented in this district; the exceptions are Groot and Klein Chwaing.

(5) *The junction of two formations.*—It is rather surprising that so little advantage is taken of the occurrence of water at the junction of two dissimilar sets of rocks. For example, the base of the Black Reef Series is markedly water-bearing, and fine springs occur at Vryburg and at Motiton.

There is one drawback to boring, namely, the excessively hard formation, which is almost impenetrable with ordinary drills.

Effect of the formation.—Over most of Bechuanaland the soil is sandy and of considerable depth, yet there appears to be but little of the water stored in it that can be made available. Consequently it is to the underlying rock that one has to turn, and as the nature of it may vary it is of great importance to discover the effect of the geological formation.

This will be briefly considered below:—

(*a*) *Granite and gneiss.*—This formation is hardly ever well exposed, and is usually covered with a mantle of reddish sandy soil.

As a rule the rock is a well-foliated muscovite-granite or muscovite-gneiss, with the foliation planes dipping at a high angle. The rock may be veined by pegmatites or traversed by quartz-reefs, both of which will probably influence the movements of underground water.

The granite and gneiss are more or less decomposed, and this alteration extends below the surface to a rather variable depth; the more micaceous gneissic varieties are usually altered to a greater degree than the compact unfoliated granites.

The reason is to be sought for in the different rates of expansion and contraction of the mineral constituents, by which planes of weakness are developed in the rock.

The very well-banded gneisses, with regular layers of quartz, felspar, mica, or hornblende, may have a high degree of fissility imparted to them through this process, aided by mineral decomposition. This condition is favourable for the penetration and retention of rain-water.

In boring, as long as the core brought up shows cavities and fissures, or the felspars are clouded or kaolinised, there is always a possibility of obtaining water. If, however, the core shows a perfectly sound, fresh, compact granite, it may be advisable to stop. In some cases the apparently solid rock has contained numerous minute cavities, hardly visible to the naked eye, and the borehole has yielded a considerable supply.

The more compact varieties of granite—and in this category we may include quartz-porphyry—will in most cases yield but little or no water. A formation of quartz-porphyry, such as that between Vryburg and Genesa, should as far as possible be avoided.

In boring or sinking spots should not be chosen where the granitic rock forms marked outcrops, and by preference sites should be selected where there are pans on the formation.

Generally speaking, the granite is a most uncertain rock in which to bore for water, and failures may continually be expected.

A diamond drill is the best for the purpose, as a jumper will often be unable to penetrate the less weathered varieties unless with great difficulty.

(*b*) *The diabase formation.*—This commonly forms flattish ground, and from it excellent supplies of water are obtained as a rule, sometimes from remarkably shallow depths. Especially is this so in depressions and pans and along stream-courses.

The formation, which is composed principally of igneous material, consists of layers of differing composition and texture, while much of the lava is amygdaloidal.

Down to a certain depth the diabase is full of cavities and fissures, but beyond that, at a distance of a few hundred feet below the surface, the rock becomes massive, and the finer-grained varieties may be absolutely waterless. We have, for example, a dry borehole over 500 feet deep in this formation at Vryburg Station.

(*c*) *The dolomite.*—This, as a rule, provides the best water supply, and fortunately is a formation of great thickness and one covering a vast area.

Water is usually met with not many feet below the surface, and on the flats between Vryburg and Kuruman there are several places where open water exists all the year round. Springs are not uncommon, and from them in not a few places abundant, and in some cases inexhaustible, supplies of water have been obtained.

The rock is well bedded and traversed by numerous joints, which have often been widened by atmospheric agencies and solution.

This produces a condition favourable to the downward passage of water; but if the process has gone on extensively, it may lead to the transference of the water to deeper levels.

There is no evidence as yet to show whether the movement of the underground water in the dolomite is considerable or rapid. This is a point of the utmost importance, for the rainfall in the east is very much higher than that in the west, and any transference of water from east to west will increase the underground supply in the region of lower rainfall.

There is a prevalent opinion that an underground river exists beneath the Kaap Plateau; an examination of the Kuruman district will probably give much information about the movements of water in the dolomite.

There are numerous layers and concretions of quartzite and chert in the dolomite which may render boring operations costly and laborious.

(*d*) *Other formations.*—The Dwyka formation, although of a very clayey nature, gives a fair supply of water within the town of Vryburg. The water is, however, hard, and has a faintly brackish flavour.

Certain chloritic slates and phyllites associated with magnetic-quartzites give excellent supplies, *e.g.*, at Kraaipan, but it is not often that advantage can be taken of these beds.

It is clear that however water-bearing a geological formation may be, there is always a limit to the amount that can be removed from it; therefore it is essential that we should consider the influences that tend towards the accumulation of water underground.

(1) *Rainfall.*—This is by far the most important factor, and it is unfortunate that records are available for but a few stations and date back for only a short period. When the great fluctuation in the value of the annual rainfall is taken into account, it is clear that a long series of continuous observations will be required before anything approaching the true mean can be obtained.

The following values are therefore only approximations: Mafeking, 26 inches; Vryburg, 24; Groot Boetsap (on the Kaap Plateau), 23; Campbell, 15; Griqua Town, 16; and Kimberley, 20.

There are no records of observations from Kuruman or from points further to the north or west, but from an examination of the curves of mean annual rainfall, which trend somewhat north and south, there appears to be a considerable falling off in the amount of rain as one proceeds towards the Southern Kalahari.

This rainfall occurs almost entirely during the four summer months, and for the rest of the year the amounts registered are comparatively insignificant.

There can be no doubt that in former times, within the last century, the rainfall over this portion of South Africa was much greater than that of the present day; this is a matter of the highest importance.

Though the testimony of the earlier travellers is neither unanimous nor conclusive, the existence of river gravels at levels far above the present river-beds, and the deep cuttings made by the rivers themselves through ridges of hard rock, show that at the present day the rate of excavation and erosion is very much smaller than was the case in times past.

Whether the present diminution is merely a temporary one, to be followed by a gradual return to former conditions, is not by any means evident; but it will be best in our considerations to ignore such a possibility.

Of all this quantity of water that falls upon the surface of the ground, none of it, if we except the Dry Harts River, makes its way to the sea; that is, the run-off over this area is *nil.* Since practically there is no loss in this way, the whole of the rainfall will have to be accounted for by the processes of storage, evaporation, and transpiration; and while the addition of water to the subsoil can take place during a very small fraction of the year only, its removal goes on day after day throughout that period.

(2) *Penetrative power of water.*—It is a commonly noticed fact that after a thunderstorm of the average intensity the soil is still quite dry at a depth of a few inches below the surface, the precise distance varying for different soils.

The downward passage of the rain is greatly influenced by the porosity of the soil, *i.e.*, the ratio of the space between the sand-grains to the volume occupied by the sand itself; the larger these grains are the more rapidly does the water sink down. During, and immediately after, rain capillary action aids gravity, but as soon as the surface soil becomes drier than that below the action is reversed and the flow due to capillarity is upwards.

Hence the immense importance of periods of prolonged humidity, even if they are followed by intervals of lesser rainfall. This has been shown clearly by experiment* as well.

Along ridges and watersheds very little moisture is able to penetrate the soil, but in hollows and valleys the conditions are very much more favourable.

(3) *Evaporation and transpiration.*—By far the greater loss must occur directly from the surface, more especially as the rain falls during the heat of summer. The rate of evaporation depends not so much upon the temperature as upon the humidity of the air. There are no records available for this area, but at Kimberley, where the conditions are very similar, the mean annual humidity has the low value of 55 per cent.

Not only does evaporation take place directly from the surface after rainfall, but moisture is brought up from below ground by capillary action and so dissipated; the formation of calcareous tufa by this means has already been noted.

Some experiments made by Prof. F. H. King† show that the capillary movements of water are considerable even at a distance of 4 feet below ground; hence moisture is readily brought up from such a depth and evaporated. The importance of the rapid descent of the moisture through the soil is thus made apparent. They also indicate what has been proved in other ways, that, in the case of light showers, all the water is brought back to the surface and evaporated before it can get below the critical depth. Another source of loss is the transpiration of moisture by vegetation. Bechuanaland is fairly thickly clothed, and the roots of some of the thorn trees descend to depths of over 80 feet in search of nutriment. The amount of moisture transpired by a tree of average size is estimated at from 2 to 2½ gallons daily, but I am unable to obtain any figures for the transpiration losses per square mile of wooded country. The removal of water by vegetation must, however, take place on an immense scale annually.

Proportion of rainfall retained.—From the preceding paragraphs it is clear that this depends upon quite a number of factors, *e.g.*, whether the rainfall is above or below the mean, upon the porosity of the soil and the rock underlying, upon the depth down to decomposed material and thence to unfissured rock, upon the slope of the surface, upon the amount of vegetation it supports, &c.

I think, though, that if we consider the annual rainfall to be nearly constant, the amount of moisture supplied to the soil must just balance the quantity lost, *e.g.*, the quantity actually added has a *zero* value. Should these two processes not exactly balance one another, a tendency will be established which will in time become intensified, so that after a certain period the physical aspect of the country will be entirely altered.

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* Prestwich, "Water Supply of London," p. 113, 1895.

† King, "Nineteenth Annual Report United States Geological Survey," vol. ii., p. 85, &c., 1899.

It is, I consider, only in the years of abnormal rainfall that the additions more than balance the losses, and that the average level of the ground water is actually raised.

What exact effect a period of very low rainfall has is not quite so clear, but possibly the losses may not increase in the ratio expected. It must not be lost sight of that the present abundance of underground water may in part represent the result of gradual accumulation during the former period of higher rainfall.

Amount available.—So far yet we have not taken into consideration the disturbing effect of the artificial removal of water as a consequence of human occupation.

We may take the average depth at which water is found on sinking a well in this area at 50 feet; some wells in the district are over 100 feet in depth, and there is one example as much as 140 feet deep.

A certain number of wells have had to be deepened from time to time, as the water was removed from the rock and as the supplies had to be drawn from points further distant. The practical limiting depth, however, may be taken at 150 feet.

The whole of the moisture contained in any given volume of saturated soil cannot be entirely withdrawn; experiments show that even after several years of draining about 20 per cent. is still retained. After wells have served their purpose, boreholes may be employed to drain the lower levels, but it must be remembered that the pore-space in rocks diminishes as we descend, so that the advantage gained in depth will finally be set off by the diminished porosity of the water-bearing material.

The movement of water underground towards wells and boreholes is slow, and varies considerably for different materials; for average sandy soils and pressure gradients the velocity* of flow is from 1 to 2 miles per annum. The rate decreases very rapidly with diminished porosity, and in decomposed rock the velocity must be extremely small indeed.

It may therefore happen that a well will show a gradual falling off in its yield. This may be got over by sinking fresh wells, but they should be so far distant from one another that they do not interfere.

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* C. Slichter, "Motions of Underground Waters." United States Geological Survey, Water Supply and Irrigation Papers, No. 67, p. 26, 1902.

The effects of extensive and prolonged draining of the soil are becoming very marked in several countries, sometimes so much so as to give reasonable cause for alarm.

In Southern California* in the last ten years the level of the ground water has been lowered at various places from 30 to 90 feet over extensive areas.

This is worthy of special attention, because this portion of North America in certain respects resembles Bechuanaland, as the region is one of low rainfall and the flow in the rivers is lost in the sands of the plains which extend along the foot of the Sierra Nevada.

In London,† during the last 30 years, the level of the water in the chalk and lower tertiary sands has fallen a distance of from 40 to 60 feet; in this case, however, the drain upon the resources of the basin has been excessive.

Conclusion.—In the foregoing I have endeavoured to point out the various influences—some beneficial, others adverse—that affect the underground water supply, and though I may have given rather greater prominence to the latter, it is chiefly with the object of drawing attention to a matter of no small importance.

There is much need for extended study of the conditions for and against the accumulation of water, and of experiments in order to determine how great a proportion of the annual rainfall is actually available, and how this amount is affected by periods of abnormal rainfall or of unusual drought. Not only does this apply to Bechuanaland but to all parts of South Africa, though each district will have influences that will modify these problems.

As regards supplies in this area I think that we can only rely upon shallow wells and boreholes of no great depth. I have only come across a few spots where the conditions are apparently favourable for artesian supplies; but such occurrences are strictly limited, and the areas so favoured are of but small extent.

Wells have the disadvantage over boreholes in the matter of depth and cost, while in places where the soil is sandy and deep the walls may require supporting by means of cribs with linings of wood or sheet-iron; this has been done in some of the wells beyond Genesa.

Towards the Kalahari this difficulty may perhaps be overcome by the employment of drive-wells, *e.g.*, tubes perforated at their lower extremities and furnished with conical brass penetrating points. They are driven down through the sand until the saturated soil is penetrated. Over most of this area, however, the depth of soil is probably not sufficient to warrant their adoption.

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* United States Geological Survey, Monograph xlvii., p. 427.

† Prestwich, "Water Supply of London," p. 189, 1895.

In some of the valleys sub-surface dams might be built, and by that means the water, which under ordinary conditions makes its way slowly down below the river-bed, brought up to the surface. Such a dam is constructed by excavating a trench across the (dry) river-channel, extending it down to the bed-rock, and then filling it with masonry.

This system has been extremely successful in California, and there are numerous places here where similar dams could be built, *e.g.*, down the Molopo and Setlagoli Rivers.

With regard to boring for water I do not think that it is advisable to go beyond a depth of 400 feet; such few borings as have exceeded this do not yield any great supply.

The question of size of borehole is of no great importance; the advantage of a 6-inch hole over a 4-inch one is to a great degree imaginary, as their actual relative capacities have the ratio 100 to 95.[*]

In conclusion, I think that for many years to come the underground supplies will prove sufficient for average needs, although it is improbable that anything great will be done in the way of irrigation.

As a cattle-raising country this part of the Cape Colony is unequalled, and when the great tracts of ground, thickly covered with grass and bush and as yet unoccupied and unsurveyed, are considered, it is to be hoped that greater facilities and inducements may be given by the Government to persons desirous of settling here, so that the potentiality of this vast area may in the future become a reality.

[*] C. Slichter, *loc. cit.*, p. 85.

A SET OF LINEAR EQUATIONS CONNECTED WITH HOMOFOCAL SURFACES.

By Thomas Muir, LL.D.

(Read February 28, 1906.)

1. It is usually stated that the set of equations

$$\left.\begin{array}{l}
\dfrac{x_1}{b_1-\beta_1}+\dfrac{x_2}{b_1-\beta_2}+\dfrac{x_3}{b_1-\beta_3}+\ldots+\dfrac{x_n}{b_1-\beta_n}=1 \\
\dfrac{x_1}{b_2-\beta_1}+\dfrac{x_2}{b_2-\beta_2}+\dfrac{x_3}{b_2-\beta_3}+\ldots+\dfrac{x_n}{b_2-\beta_n}=1 \\
\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
\dfrac{x_1}{b_n-\beta_1}+\dfrac{x_2}{b_n-\beta_2}+\dfrac{x_3}{b_n-\beta_3}+\ldots+\dfrac{x_n}{b_n-\beta_n}=1
\end{array}\right\}$$

was first solved by Binet[*] in 1837; and it is certainly true that subsequent to that date additional solutions were given by Chelini, Cauchy, Hädenkamp, and Liouville.[†] The solution given in Todhunter's "Theory of Equations," where a reference is misleadingly made to Grunert's "Archiv," is really Liouville's.

The object of the present note is to make known a solution which, though simpler than any of those mentioned, is not brought forward wholly on that account, but also in order to draw pointed attention to a paper of Murphy's in which is given a *general mode* of dealing with equations of the type above exemplified, and which bears a date five years prior even to Binet's paper.[‡]

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[*] Binet, J., "Observations sur des théorèmes de géométrie . . ." (Journ. (de Liouville) de Math., ii., pp. 248–252).

[†] Chelini, D., "Formazione e dimostrazione della formula che dà . . ." (Giornale Arcadico lxxxv. (1840), pp. 3–12).

Cauchy, A., "Mémoire sur les fonctions alternées . . ." (Exercices d'analyse et de phys. math., ii. (1841), pp. 151–159).

Hädenkamp, "Ueber Transformation vielfacher Integrale "(Crelle's Journ., xxii. (1841), pp. 184–192).

Liouville, J., "Sur une classe d'équations du premier degré" (Journ. (de Liouville) de Math., xi. (1846), pp. 466–467).

[‡] Murphy, R., "On Elimination between an Indefinite Number of Unknown Quantities" (Trans. Cambridge Philos. Soc., v. (1832), pp. 65–76).

2. The essence of the solution consists in noting that to assert the validity of the given set of equations is the same as to say that the expression

$$\frac{x_1}{\xi-\beta_1}+\frac{x_2}{\xi-\beta_2}+\frac{x_3}{\xi-\beta_3}+\dots+\frac{x_n}{\xi-\beta_n}=1$$

vanishes for n values of ξ, namely, the values $b_1, b_2, \dots, b_n$; and that therefore

$$\begin{aligned} x_1(\xi-\beta_2)(\xi-\beta_3)\dots(\xi-\beta_n) \; + \; x_2(\xi-\beta_1)(\xi-\beta_3)\dots(\xi-\beta_n) \; + \; \dots\dots \\ - \quad (\xi-\beta_1)(\xi-\beta_2)\dots(\xi-\beta_n) \end{aligned}$$

must be identically equal to

$$A(\xi-b_1)(\xi-b_2)\dots(\xi-b_n).$$

Since the only term containing ξ^n in the left-hand member is $-\xi^n$, it follows that A is -1. We have only then to put $\xi=\beta_1, \beta_2, \dots$ in succession in this identity and we obtain

$$x_1=-\frac{(\beta_1-b_1)(\beta_1-b_2)\dots(\beta_1-b_n)}{(\beta_1-\beta_2)\dots(\beta_1-\beta_n)}, \quad x_2=\dots\dots\dots$$

3. As a second example, which readily suggests others, let us take the set

$$\left.\begin{aligned} a_1x_1+a_1^2x_2+a_1^3x_3+\dots+a_1^nx_n &= -1 \\ x_1+2a_1x_2+3a_1^2x_3+\dots+na_1^{n-1}x_n &= 0 \\ a_2x_1+a_2^2x_2+a_2^3x_3+\dots+a_2^nx_n &= -1 \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ a_{n-1}x_1+a_{n-1}^2x_2+a_{n-1}^3x_3+\dots+a_{n-1}^nx_n &= -1 \end{aligned}\right\}.$$

Here the equivalent assertion is that the expression

$$1+\xi x_1+\xi^2x_2+\xi^3x_3+\dots+\xi^nx_n$$

vanishes for $n-1$ values of ξ, namely, the values $a_1, a_2, \dots, a_{n-1}$, and that its differential-quotient with respect to ξ vanishes for $\xi=a_1$. We thus learn that it is of the form

$$A(\xi-a_1)^2(\xi-a_2)(\xi-a_3)\dots(\xi-a_{n-1}):$$

and observing that it becomes 1 when ξ is put $=0$ we learn further that

$$A=\frac{(-1)^n}{a_1^2a_2a_3\dots a_{n-1}}.$$

Our identity thus is

$$1+\xi x_1+\xi^2 x_2+\ldots+\xi^n x_n=\frac{(-1)^n(\xi-a_1)^2(\xi-a_2)(\xi-a_3)\ldots(\xi-a_{n-1})}{a_1^2 a_2 a_3\ldots a_{n-1}},$$

and equating coefficients of like powers of ξ we obtain

$$x_n\;=\frac{(-1)^n}{a_1^2 a_2 a_3\ldots a_{n-1}},$$
$$x_{n-1}=\frac{(-1)^{n+1}(2a_1+a_2+a_3+\ldots+a_{n-1})}{a_1^2 a_2 a_3\ldots a_{n-1}},$$

....

4. The close connection of these with the cases considered by Murphy will be evident when we quote what he calls his "principle," which is, "If we make the right-hand member of the ξth equation disappear by transposition, the left-hand member is then a function of ξ which vanishes when ξ is any member of the series 1, 2, 3, ..., n: and therefore it must be of the form $P(x-1)(x-2)(x-3)\ldots(x-n)$." His cases are those where the ξth equation is

$$(a)\;\; \frac{1}{\xi}+\frac{x_1}{\xi+1}+\frac{x_2}{\xi+2}+\ldots+\frac{x_n}{\xi+n}=0,$$
$$(b)\;\; 1+\xi x_1+\xi(\xi+1)x_2+\ldots+\xi(\xi+1)\ldots(\xi+n-1)x_n=0,$$
$$(c)\;\; 1+\xi x_1+\xi^2 x_2+\ldots+\xi^n x_n=0.$$

RECENT INFORMATION CONCERNING SOUTH AFRICAN FERNS AND THEIR DISTRIBUTION.

By T. R. Sim, F.L.S.,
Conservator of Forests, Natal.

(Read February 28, 1906.)

Plates IV., V.

When in 1892 I prepared a handbook on "The Ferns of South Africa," I carefully examined practically all the herbarium material available in South Africa, and with some assurance ended the Preface with these words: "I do not anticipate that many more species of ferns will ever be found in Cape Colony, but the whole region north of the Orange, Vaal, and Umfolozi Rivers is still, botanically, almost a *terra incognita*, and doubtless contains many still unrecorded species."

Further on it is stated, "It would be most misleading to say that the species which have been recorded from the Orange Free State, Transvaal, Kalihari, Matabeleland, and Mashonaland are all that exist in them, or even in any way representative of what does exist in them; and the records from these parts are merely given here as a quota towards the much fuller knowledge of these districts which another decade will likely give us. A more correct definition of the area which has been in any measure satisfactorily examined would restrict it to a belt of country, less than 100 miles wide, stretching all round the coast from the mouth of the Orange River to the northern border of Natal—1,500 miles or thereby. To this might be added the Karroo region, which is known to have only a very limited number of species of ferns, and some of these peculiar to it."

Further investigation has proved this to be the case. The northern colonies have proved much richer in ferns than the previous lists indicated; the coast colonies remain nearly as they were.

After an interval of thirteen years the additional species of ferns and fern allies to be recorded from Cape Colony, Natal, and Zululand, taken collectively, number only seven, viz., *Adiantum sulphureum*, *Nephrolepis exaltata*, *Lygodium scandens*, *Ophioglossum nudicaule*, *Ophioglossum lusitanicum*, *Lycopodium dacrydioides*, and *Isoetes Wormaldii*, and no proof has come to hand that any species then described was included in error, or should not hold specific rank. New localities have been noted, extending somewhat the range of many other species, and admitting them into regions where they were formerly unrecorded, but otherwise I have no alteration to make in regard to that area.

But with regard to the Orange River Colony, Transvaal, and Rhodesia the case is different. The development and settlement of these colonies, and the more easy access to them by rail, has given opportunity for botanical collecting which did not previously exist, and though their fern floras are still by no means thoroughly known, the collections in hand yield data worth record as a guide to collectors, and a further contribution toward a more complete list than is yet possible. It is probable also that many specimens collected in these upper colonies, especially during the Boer War, found their way to Europe, and that the material there tells more than does that which I have seen.

The geographical area dealt with in "The Ferns of South Africa" was nominally that part of continental Africa lying south of the tropic of Capricorn. This included the Transvaal but only part of Rhodesia, and the latter was only represented by bare lists of about 30 species.

Railway development and present political boundaries, as well as the United South Africa of the future, all render it desirable that South Africa, as a fern district, should be extended northward so as to include the whole of Rhodesia as well as the adjacent Portuguese country south of the Zambesi. From the latter, which is doubtless rich in ferns, I have as yet no specimens or records, and in this respect the present list is certainly incomplete. Species probably belonging to that area and northward extend into Rhodesia and the Transvaal, and also into Natal, but their presence in Portuguese country can only be assumed. The Transvaal contains two distinct climatic conditions, the one dry and cold, corresponding in its fern flora with the Orange River Colony and Upper Karroo, while the other is moist and warm and includes tropical species, some of which do not extend further south.

Rhodesia has also two climates, the dry corresponding with that of the Transvaal and Bechuanaland, the other the moist, warm climate which the coastward portions of the Transvaal and Natal enjoy, and which also extends northward, introducing in Zambesia many tropical species of which the distribution there and northward is not yet definitely ascertained.

The Orange River Colony is hardly a fern country, being mostly dry and unfavourable, but in the north-eastern portion, and especially where it meets Natal and Basutoland, there are fern-kloofs from which I have had 19 species, and probably the list will yet be much extended.

In consideration of the numerous additional species recorded from the Transvaal, Rhodesia, and Orange River Colony, it has been considered advisable to make this not only a new check-list for the whole of South Africa, but also a full record of localities for these upper colonies, according to present information, including, for convenience, such localities as were recorded in "The Ferns of South Africa," together with what have since been ascertained. It has also been decided to note therein such extension of distribution in Cape Colony and Natal as is worthy of record, though not to repeat the Cape and Natal localities previously well worked up.

The arrangement into districts has been as formerly, viz.: (1) Cape, Western; (2) Cape, Eastern; (3) Kaffraria; (4) Natal; (5) Orange River Colony; (6) Transvaal; (7) Rhodesia; and for a few of which the exact habitat is not ascertained Zambesia is also given, as indicating localities probably in Rhodesia, but also possibly north of the Zambesi, or in Portuguese territory.

Madagascar has not been dealt with here, and it is remarkable that though an enormous number of new species have during recent years been found in Madagascar, the ferns and fern-allies of continental South Africa, in so far as I have seen them, have all belonged to previously described species, with the exception of two, viz., *Isoetes Wormaldii* from East London, and *Davallia Hollandii* from Rhodesia.

The Transvaal localities formerly recorded were mostly from the collections of Sanderson, Burke, Zeyher, Maclea, Ayres, and Bolus; and those from Rhodesia from the collections of Oates, Waller, Sir John Kirk, and Ffolliott-Darling.

Since then Mr. R. Schlechter, Mr. Eastwood, and Mr. J. Burtt-Davy have sent considerable contributions from the Transvaal; Mr. W. A. Quail sent a collection from Ficksburg, Orange River Colony; Mr. B. A. Holland (Rondebosch) made a very complete collection of Rhodesian ferns in 1904; Mrs. Bennett made a fine collection from the neighbourhood of Umtali, which was shown at the Capetown Exhibition this year, and to which she has since added many specimens; Mr. G. Richards, M.L.A. (Natal), and Mr. Allen, of Rhodesia, collected at the Victoria Falls in 1904; Mr. H. Marshall-Hole, C.C. and R.M., Salisbury, sent specimens from his neighbourhood in 1894, and many others have made smaller Rhodesian contributions; while in Cape Colony Mr. H. G. Flanagan, F.L.S., has continued to collect what was new to him or not recorded before, and Dr. Bolus and Dr. Marloth have also been adding. My own collections have been made in the Cape Colony, Natal, Zululand, Transvaal, and

Orange River Colony, but without touching the best parts of the Transvaal or any part of Rhodesia.

I have also recently inspected the Government Herbarium of Natal, from which Mr. J. M. Wood, A.L.S., sent me a very full set when my previous work was in hand, but which now contains several additional items of interest. Other public and private herbaria in South Africa are stated by their owners or curators to contain little additional material of this kind since last I examined them.

The following list is compiled from specimens which have passed through my hands, or from reliable records, and shows a total of 212 species, comprising 186 ferns and 26 fern-allies. Natal is the district having the highest number of recorded species (147); probably this is accounted for by its having warm coast and forest as well as cold mountain regions, and possibly also through its having had closer investigation than the others. Records in hand show the distribution to be as follows:—

	Not recorded elsewhere in South Africa.	Total.
Cape Colony, Western Districts	17 species	95 species
Cape Colony, Eastern Districts	2	86
Cape Colony, Kaffraria (including Transkei)	2	108
Natal	15	147
Transvaal	7	90
Rhodesia	11	86
Zambesia	15	20
Orange River Colony	1	19
Cape Colony, West and East	20	113
Cape Colony, East and Kaffraria	4	115
Kaffraria and Natal	20	152
Natal and Transvaal	28	161
Transvaal and Rhodesia	21	129
Rhodesia and Zambesia	26	105
West, East, and Kaffraria	22	138
East, Kaffraria, and Natal	25	155
Kaffraria, Natal, and Transvaal	40	165
Natal, Transvaal, and Rhodesia	55	172
Transvaal, Rhodesia, and Zambesia	36	145
Natal, Transvaal, Rhodesia, and Zambesia	72	188

Common to West, East, Kaffraria, Natal, Transvaal, and Rhodesia, 25 species, of which 8 are also recorded from the Orange River Colony.

Several species have been received in imperfect condition, mostly barren, which add at least half a dozen to the present list, though they cannot be identified from the material in hand.

Two genera have been added to the previous list, viz., Platycerium and Lygodium, the latter being represented by two species. Illustrations of these and several other additions are attached.

Further contributions of specimens will be thankfully received with a view to adding what still remains absent from the present list.

SPECIES CONFINED IN SOUTH AFRICA TO THE RESPECTIVE DISTRICTS OR GROUPS OF DISTRICTS, SO FAR AS PRESENTLY KNOWN.

West.	East.	Kaffraria.	Natal.	Transvaal.	Rhodesia.	Orange River Colony.	Zambesia.	Numbers in attached List of Species.	Number of Species.
×	—	—	—	—	—	—	—	6, 11, 39, 41, 45, 48, 50, 51, 53, 56, 93, 148, 154, 159, 182, 183, 184 ...	17
×	×	—	—	—	—	—	—	31	1
×	×	×	×	—	—	—	—	16, 36, 43, 57, 67, 73, 74, 95, 110, 137, 152, 172, 173, 192, 211 ...	15
×	×	×	×	×	—	—	—	4, 13, 35, 40, 141, 161, 185, 190, 193, 194	10
×	×	×	×	×	×	—	—	20, 44, 59, 66, 72, 75, 82, 83, 90, 97, 102, 117, 139, 143, 171, 181, 187	17
×	×	×	×	×	×	×	—	42, 54, 61, 64, 70, 122, 153, 177 ...	8
×	×	×	×	—	×	×	—	29, 94, 108	3
×	×	×	×	×	—	×	—	1, 76, 151	3
×	×	×	×	—	—	×	—	9	1
×	×	×	×	—	×	—	—	80, 86, 121, 123, 158...	5
×	×	×	×	×	—	—	×	37	1
×	×	×	×	—	×	—	×	120	1
×	—	×	×	—	×	—	—	126	1
×	×	—	×	×	—	—	—	170	1
×	×	—	×	—	—	—	—	68, 138...	2
×	—	×	×	—	—	—	—	162, 198	2
×	—	×	×	×	—	—	—	212	1
×	—	—	×	—	—	—	—	188, 196, 202	3
×	—	—	—	×	—	—	—	209	1
×	—	—	—	×	×	—	—	46, 106...	2
—	×	—	—	—	—	—	—	30, 210...	2
—	×	×	×	—	—	—	—	81, 88, 109	3
—	×	×	×	×	—	—	—	78, 96, 113	3
—	×	×	×	—	×	—	—	84	1
—	×	×	×	×	×	—	—	32, 49, 63, 87, 105, 199	6
—	×	—	×	×	—	—	×	186	1
—	×	×	×	×	×	×	—	197	1
—	×	×	—	—	×	—	—	22	1
—	—	×	—	—	—	—	—	78, 208...	2
—	—	×	×	—	—	—	—	18, 71, 165	3
—	—	×	×	×	—	—	—	2, 17, 125, 133, 150, 176	6
—	—	×	×	×	×	—	—	15, 65, 119, 124, 157, 189	6
—	—	×	×	—	×	—	—	100, 104, 118, 146, 147	5
—	—	×	—	×	—	—	—	112	1
—	—	×	×	×	—	—	×	111	1
—	—	×	—	—	—	×	—	33	1
—	—	—	×	—	—	—	—	5, 10, 12, 23, 24, 85, 89, 101, 132, 144, 164, 179, 195, 203, 207 ...	15
—	—	—	×	×	—	—	—	14, 19, 52, 155, 174	5
—	—	—	×	×	×	—	—	3, 62, 79, 149	4
—	—	—	×	—	×	—	—	103, 107, 115, 131, 134, 135, 140, 142, 160, 163, 186	11
—	—	—	×	×	—	×	—	156	1
—	—	—	×	×	—	—	×	191	1
—	—	—	—	×	—	—	—	7, 26, 55, 60, 128, 200, 201	7
—	—	—	—	×	×	—	—	25, 98, 175	3
—	—	—	—	—	×	—	—	21, 27, 28, 38, 47, 58, 129, 130, 169, 180, 205	11
—	—	—	—	—	—	×	—	202	1
—	—	—	—	—	—	—	×	8, 34, 68, 91, 92, 99, 114, 116, 127, 136, 145, 166, 167, 178, 204... ...	15
								Total	212

LIST OF SOUTH AFRICAN FERNS AND FERN ALLIES, AND OF SOUTH AFRICAN LOCALITIES.

(Localities recorded in "Ferns of South Africa" and not repeated here are marked F. of S. A.)

1. *Gleichenia polypodioides*, Smith.
   West, East, Kaffraria, Natal (F. of S. A.):—Engcobo Mountains (Flanagan 2714).
   Orange River Colony:—Rouxville Dist. Ficksburg (Quail).
   Transvaal:—Mamotsinri (Burtt-Davy 213).
2. *Gleichenia umbraculifera*, Moore.
   Kaffraria and Natal (F. of S. A.):—Engcobo Mountains (Flanagan 2691).
   Transvaal:—Near Lydenburg (Dr. W. G. Atherstone). Pilgrim's Rest (Roe). Mamotsinri (Burtt-Davy 209).
3. *Gleichenia dichotoma*, Willd.
   Natal (F. of S. A.):—Near Inchanga (J. M. Wood).
   Transvaal:—Mauchsberg to Sabie Valley (Burtt-Davy 468). Haenertsberg (Eastwood).
   Rhodesia:—Umtali (Mrs. Bennett, who states that it prefers shady banks overhanging water).
4. *Hymenophyllum rarum*, R. Br.
   West (F. of S. A.):—Sir Lowry's Pass (Schlechter 7838).
   East, Kaffraria, and Natal (F. of S. A.).
   Transvaal:—Houtbosch, 6,800 feet (Schlechter, mixed in his 4758, *Lycopodium gnidioides*).
5. *Hymenophyllum gracile*, Bory.
   Natal (F. of S. A.).
6. *Hymenophyllum obtusum*, Hk. & Arn.
   West (F. of S. A.).
7. *Hymenophyllum lineare*, Sw.
   Transvaal:—I have seen no South African specimen, but Lady Barkly and Buchanan give "Macamac, Transfield Goldfields, specimens recently sent by Mr. Ayres."
8. *Hymenophyllum ciliatum*, Sw. (= *H. Boryanum*, Willd.).
   Rachis broadly winged, frond ciliated and hairy. Differs from *H. obtusum* in having a broad central undivided portion in the lower pinnæ, and in its immersed involucre.
   "Zambesi district" (Synopsis Filicum).
9. *Hymenophyllum Tunbridgense*, Smith.
   West, East, Kaffraria, and Natal (F. of S. A.).
   Orange River Colony (T. Cooper 1045, 1862).

10. *Trichomanes muscoides*, Sw.

Natal (F. of S. A.).

11. *Trichomanes digitatum*, Sw.

Cape (F. of S. A.).

12. *Trichomanes pusillum*, Sw.; var. *quercifolium*, Hk. & Gr.

Natal (F. of S. A.).

13. *Trichomanes pyxidiferum*, Linn.

West, East, Kaffraria, and Natal (F. of S. A.):—Near Umtata, 3,700 feet (Flanagan 2647).

Transvaal:—Macamac and Pilgrim's Rest (McLea & Herb. Bolus 3019). Mamotsinri (Burtt-Davy 212).

14. *Trichomanes rigidum*, Sw.

Natal (F. of S. A.).

Transvaal:—Drakensberg near Macamac (J. H. McLea). Mamotsinri, common (Burtt-Davy 210).

15. *Cyathea Dregei*, Kunze.

Kaffraria and Natal (F. of S. A.).

Transvaal:—Magalisbergen (Burke; Zeyher 1862). Macamac (McLea). Houtboschberg, 6,700 feet (Schlechter 4460). Barberton Mountains (Burtt-Davy 329). Kloofs everywhere (Burtt-Davy 220).

Rhodesia:—Penhalanga (Mrs. Bennett). Umtali (Holland). Moramballa Mountains (Waller; Livingstone; Kirk).

Many new species of *Cyathea* have recently come from Madagascar, and a few from Central Africa, including *C. Thomsoni* (Bkr. Jour. Bot., 1881, 180), which is very near *C. Dregei*, from near Lake Nyassa.

Forms of *C. Dregei* occur together in Natal which are evidently but indescribably different.

16. *Hemitelia capensis*, Br.

West, East, Kaffraria, and Natal (F. of S. A.).

Letters from Rhodesia speak of a tree-fern with tall, slender stems, but no fertile specimen has come to hand.

17. *Woodsia Burgessiana*, Gerrard.

Kaffraria:—Eastern Province (Lady Barkly). Windvogelberg, Cathcart, Nov., 1897 (T. R. Sim). Near Ugie, 5,100 feet (Flanagan 2672).

Natal (F. of S. A.).

Transvaal:—(Lady Barkly). Houtboschberg, 6,500 feet (Schlechter 4705).

18. *Davallia nitidula*, Kunze.

Kaffraria (F. of S. A.):—Egossa. E. Pondoland, 1899 (T. R. Sim). Port St. Johns, 1896 (Flanagan 2470).

Natal (F. of S. A.).

19. *Davallia Speluncæ*, Baker.
    Natal and Zululand (F. of S. A.).
    Transvaal :—Magalisberg (Burke ; Zeyher).

20. *Davallia concinna*, Schrad.
    West, East, Kaffraria, Natal (F. of S. A.) :—Port St. John's (Flanagan 2468).
    Transvaal :—Houtbosch (Dr. Rehmann 5606). Houtboschberg, 6,500 feet (Schlechter 4700).
    Rhodesia :—Moramballa (Kirk).

21. *Davallia* (*Loxoscaphe*) *Hollandii*, Sim. (new species), Pl. IV.
    Stipe paleaceous, 6 inches long. Frond ovate-deltoid, quadripinnate, thinly coriaceous, 2 feet long, 12 inches wide below the middle, rather narrower to the base and gradually less upward. Rachis brown, fibrillose, grooved. Pinnæ 6 inches long, 2 inches wide below, with a marginal rachis and alternate pinnules, of which the lowest is on the upper side. Pinnules 1 inch long, ½ inch wide, cut into stalked segments, of which the upper are simple and the lower 3–4-fid. Ultimate segments pointed, 2–3 lines long, ½ line wide or less, their stalks narrower. Segments of barren fronds blunt. Sori abundant, lateral, short, flattened, one near the base of each ultimate segment; the involucre scarious and attached at the base and sides. A beautiful fern, resembling a finely cut *Darea*, but with davallioid sori. Well worth cultivation.
    Rhodesia :—Near Umtali (Holland ; Mrs. Bennett).

22. *Cystopteris fragilis*, Bernh.
    East (F. of S. A.).
    Kaffraria (F. of S. A.) :—Broughton, Molteno, 6,300 feet (Flanagan 1676). Engcobo (Flanagan 2715).
    Rhodesia :—Lo Magundi, near Hanyani River (H. M. Hole).

23. *Lindsaya ensifolia*, Swartz.
    Natal (F. of S. A.).

24. *Adiantum reniforme*, Linn. ; var. *asarifolium*, Willd.
    Natal (F. of S. A.) :—The fertile specimen in the Natal Government Herbarium was found among Sanderson's plants, without label.

25. *Adiantum caudatum*, Linn.
    Credited to Cape Colony in "Synopsis Filicum," probably in error.
    Transvaal (collected by Mr. Todd of Inanda) :—Avoca, Barberton (Galpin 1244).

Rhodesia:—Mazoe and Umtali (J. F. Darling). Umtali (Mrs. Bennett; Mrs. Meikle; Mrs. Eickhoff; Holland). Victoria Falls (Holland; Richards). Zambesi (Waller).

A form with winged petioles and stipes is mentioned in "Synopsis Filicum," but is not recorded here.

26. *Adiantum rotundatum*, Kunze.

Transvaal:—Wakkerstroom (Dr. Shaw; Sim 70).

27. *Adiantum lunulatum*, Burm.

Rhodesia:—Mazoe (J. F. Darling). Victoria Falls (Richards; Holland). Umtali (Mrs. Bennett). Zambesiland (Oates).

A form with winged petioles and stipes is mentioned in "Synopsis Filicum" as collected in South Africa by Drs. Kirk and Welwitsch.

28. *Adiantum Oatesii*, Baker. South Africa only.

Rhodesia:—Matabeleland (Oates). Lo Magundi (J. F. Darling).

29. *Adiantum Capillus-Veneris*, Linn.

West, East, Kaffraria, Natal (F. of S. A.).

Orange River Colony:—Ficksburg (Quail).

Rhodesia:—Mazoe (J. F. Darling). Abundant in every stream in the country (H. M. Hole). Victoria Falls (Holland). Umtali (Mrs. Bennett). Tette (Peters).

Many forms from β major to γ minor are found in all these localities, and connect these varieties by every possible gradation.

30. *Adiantum Paradiseæ*, Baker. South Africa only.

East (F. of S. A.).

31. *Adiantum thalictroides*, Willd.

West, East (F. of S. A.).

32. *Adiantum æthiopicum*, Linn.

East, Natal (F. of S. A.).

Kaffraria (F. of S. A.):—Bankies, Sterkstroom, 5,000 feet (E. D. Barker). Engcobo, 1896, 3,000 feet (Flanagan 2780).

Transvaal:—Riet-vlei, Belfast (Burtt-Davy 1235). Marovuni (Burtt-Davy 215). Haenertsberg (Eastwood).

Rhodesia:—Mazoe River (Holland). Mr. Edmond's farm near Salisbury (Holland). Matabeleland (Oates). Umtali, in the hill districts (Mrs. Bennett).

33. *Adiantum sulphureum*, Kaulf.

Kaffraria:—Dordrecht (T. R. Sim). Under rocks on hills near Cala, 1896, 4,000 feet. Well dusted on the under page when young; less so when mature (Flanagan 2838).

Orange River Colony:—Near Harrismith, not uncommon (J. M. Wood).

34. *Adiantum hispidulum*, Sw.

Frond nearly similar to that of *A. Oatesii*, but with segments and rachises densely pubescent.

Zambesiland (Synopsis Filicum).

35. *Lonchitis pubescens*, Willd.

West, East, Natal (F. of S. A.).

Kaffraria:—Evelyn Valley, 1894 (J. Leighton). Pondoland (Drège). Port St. John's (Flanagan 2474).

Transvaal:—Haenertsberg (Eastwood).

36. *Hypolepis anthriscifolia*, Presl.

West, East, Kaffraria, Natal (F. of S. A.):—Insinuka, Port St. John's (Flanagan 2477).

37. *Hypolepis Bergiana*, Hk.

West (F. of S. A.):—Zwaartrivier, 600 feet (Schlechter 2375).

East, Kaffraria, and Natal (F. of S. A.).

Transvaal:—Marovuni (Burtt-Davy 236). Zambesiland (Synopsis Filicum).

38. *Hypolepis Schimperi*, Sim. (= *Cheilanthes Schimperi*, Hk.).

Fronds tufted, glabrous, subcoriaceous, deltoid, 3 to 4 inches long and broad, quadripinnatifid; ultimate segments linear, entire or toothed. Sori between the lobes, each in a sinus. Evidently an *Hypolepis*. Abyssinia, Usuguru, Shiré Highlands, and Rhodesia.

Rhodesia:—Mazoe and Salisbury, 1893 (J. F. Darling). Jumbo Mine (Holland). Near Fort Salisbury, 1894, one patch only found (H. M. Hole).

39. *Cheilanthes pteroides*, Sw.

West (F. of S. A.):—Probably recorded in error from Orange Free State and Natal.

(For *Cheilanthes Kirkii*, Hk., see *Pellæa geraniifolia*, var.)

40. *Cheilanthes capensis*, Sw.

West, East, Natal (F. of S. A.).

Kaffraria:—Chumie Forest, Alice (Mrs. Young). Dordrecht Kloof (T. R. Sim).

Transvaal (Lady Barkly).

41. *Cheilanthes depauperata*, Baker.

West (F. of S. A.).

42. *Cheilanthes hirta*, Sw.

West, East, Kaffraria, Bechuanaland, and Natal (F. of S. A.).

Orange River Colony:—Bethulie (T. R. Sim).

Transvaal:—Houtbosch, 5,000 feet (Schlechter 4401).

Schweizer Reneke (Burtt-Davy 1670). Elim (Schinz). Pilgrim's Rest (McLea 40; Bolus 17).

Rhodesia:—Umtali (Mrs. Bennett).

C. hirta, Sw.; var. *β. contracta*, Kunze.

West, East, Kaffraria, Bechuanaland, and Natal (F. of S. A.).

Transvaal:—Johannesburg (Burtt-Davy 2122).

43. *Cheilanthes parviloba*, Sw.

West, Kaffraria, and Natal (F. of S. A.).

East (F. of S. A.):—Grahamstown, 2,200 feet (Schlechter 2726).

44. *Cheilanthes multifida*, Sw.

West, East, Kaffraria, and Natal (F. of S. A.).

Transvaal:—Mamotsinri (Burtt-Davy 207).

Rhodesia:—Zambesi (Kirk).

C. multifida, Sw.; var. *β. flexa*, Kunze.

Kaffraria:—Frankfort Hill (T. R. Sim).

Natal:—Newcastle (Buchanan).

Transvaal:—Mamotsinri (Burtt-Davy 207).

45. *Cheilanthes induta*, Kunze.

West (F. of S. A.).

46. *Cheilanthes Bolusii*, Baker.

The type specimen of this species in South Africa is only one rather poor young frond in Herb. Bolusianum, returned from Kew after Mr. Bolus had lost the remainder of his specimens in the wreck of the *Windsor Castle*. The description in "Ferns of South Africa" is therefore from insufficient material, but I have since had many specimens of a species which I believe to be *C. Bolusii*, and which shows a variation within itself, especially in connection with age, which necessitates an amended description. This plant I had at first placed under *C. multifida*, Sw., var. *β. flexa*, Kunze, but it is evidently distinct from *C. multifida*. Both species vary in size and with age and atmospheric condition, but are constant as follows:—

C. multifida, Sw. Frond oblong-deltoid, usually twice as long as wide, 3–4 pinnatifid, with a dark-brown polished rachis.

C. Bolusii, Baker. Frond triangular, about as wide as long, 4-pinnatifid; pinnæ unequally deltoid. Rachis dark-brown or almost black, polished.

In both species young fronds are finely cut and very tender, the segment-margins being reflexed, rendering the segments distant and bead-like during drought or heat. Under moist conditions, however, these are open, flat, and crowded, and when mature densely crowded, brown, and sometimes fully occupied with brown capsules under fringed scarious indusia, the frond then having a totally different appearance from the delicate-green young fronds. In both species the indusium is intra-marginal, as shown in "Ferns of South Africa," Plate XXXI., Fig. 3, though in the revolute state caused by dry atmospheric conditions the green margin is reflexed over and almost or quite hides the scarious indusium.

The Transvaal and Rhodesian specimens are mostly *C. Bolusii*, the Cape and Natal specimens mostly *C. multifida*, Sw., but each occurs beyond these limits. For *C. Bolusii* the following localities are noted:—

West (F. of S. A.).

Transvaal:—Makapans Poort, 4,800 feet, immature (Schlechter 4687). Hautboschberg, 9,000 feet, mature (Schlechter 4459).

Rhodesia:—Umtali (Holland).

47. *Cheilanthes farinosa*, Kaulf.

Frond deltoid or oblong-deltoid, bi-tripinnatifid, 4–8 inches long, 3–5 inches wide, subcoriaceous, glabrous, but coated on the under surface with white or yellowish powder. Africa, Asia, America, and Polynesia.

Rhodesia:—Victoria Falls (Richards; Holland). Matabeleland (Oates).

48. *Pellæa auriculata*, Link.

West (F. of S. A.).

49. *Pellæa geraniæfolia*, Fée (including *Cheilanthes Kirkii*, Hk., which is only a cheilanthoid condition of the same plant in which the sori are not confluent, and which condition it afterwards outgrows.)

East, Kaffraria, and Natal (F. of S. A.).

Transvaal (Herb. Bolus):—Marovuni (Burtt-Davy 233).

Rhodesia:—Mngama's Poort (J. Fry). In the walls of the temple at Zimbabye, June, 1904 (Holland). Umtali (Mrs. Bennett). Morambala Mountains, Zambesia (Kirk).

50. *Pellæa deltoidea*, Baker, and *Pellæa deltoidea*, Baker, var. *laxa*.

West (F. of S. A.).

51. *Pellæa robusta*, Hk.

West (F. of S. A.).

52. *Pellæa pectiniformis*, Baker.
    Natal (F. of S. A.).
    Transvaal (Bolus):—Marovuni, dry rocks, not common (Burtt-Davy 235).
53. *Pellæa lancifolia*, Baker.
    West (F. of S. A.).
54. *Pellæa consobrina*, Hk.
    West, East, Kaffraria, Natal (F. of S. A.).
    Orange River Colony:—Ficksburg (Quail).
    Transvaal:—Pilgrim's Rest, Macamac Fields (McLea 46). Mamotsinri (Burtt-Davy 204). Belfast (Burtt-Davy 1238).
    Rhodesia (Oates):—Mazoe and Umtali, 1892 (J. F. Darling; Mrs. Bennett).
    (*P. andromedæfolia*, Fée; see "Ferns of South Africa.")
55. *Pellæa Biovini*, Hk.
    Transvaal:—Magalisberg (Zeyher & Burke).
56. *Pellæa Namaquensis*, Baker.
    West (F. of S. A.).
57. *Pellæa involuta*, Baker.
    West, East, Kaffraria, Natal (F. of S. A.).
58. *Pellæa Doniana*, Hk.
    Frond simply pinnate or slightly more divided, oblong-lanceolate, coriaceous, glabrous except the rachis which is pubescent. Pinnæ 8–15 pairs, 2–4 inches long, ½–1 inch wide, shortly stalked, rounded at the base, tapering above. Midrib black and polished on the under surface.
    Rhodesia:—Umtali (Mrs. Bennett).
    Zambesia (Synopsis Filicum).
59. *Pellæa hastata*, Link.
    West, East, Kaffraria, Natal. The most common fern.
    Transvaal:—Johannesburg (Burtt-Davy 2123). Marovuni (Burtt-Davy 229). Belfast (Burtt-Davy 1245). Barberton Mountains, Lomatie Valley (Burtt-Davy 326). Haenertsberg (Eastwood).
    Rhodesia:—Salisbury (H. M. Hole). Umtali (Mrs. Bennett). Jumbo Mine (Holland). Zimbabye Ruins (Holland). Moramballa Mountains (Kirk).

Pellæa hastata, Link.; var. *macrophylla*.
Common along with the type in all forests.

Pellæa hastata, Link.; var. *glauca*. (Two forms. One usually larger, one constantly small.)
East, Kaffraria, and Natal (F. of S. A.).

Transvaal:—Houtboschberg, 6,000 feet (Schlechter 4431).
Rhodesia:—Mazoe and Salisbury (J. F. Darling; H. M. Hole; Holland). Matabeleland (Fry).

60. *Pellæa leucomelas*, Baker.
Transvaal (F. of S. A.).

61. *Pellæa calomelanos*, Link.
West, East, Kaffraria, and Natal:—Frequent.
Orange River Colony:—Wepener (Harper). Ficksburg (Quail).
Transvaal:—Magalisberg (Zeyher; Burke). Shilouvane (Junod 519). Marovuni (Burtt-Davy 231). Crocodile and Magalies Rivers (Burtt-Davy 212). Waterval Boven (Burtt-Davy 1436).
Rhodesia:—Matoppas, near grave of C. J. Rhodes (Holland). Salisbury (H. M. Hole). Matabeleland (Fry). Umtali (Mrs. Bennett).

62. *Pellæa Burkeana*, Baker.
Natal:—Rare (Wood). Great Noodsberg, Inanda, Umpumulo (Buchanan).
Transvaal:—Magalisberg (Burke).
Rhodesia:—Mazoe and Salisbury (J. F. Darling). Umtali (Holland; Mrs. Bennett). Borrowdale (H. M. Hole). A tasselled form at Salisbury (J. F. Darling).

63. *Pteris longifolia*, Linn.
East, Kaffraria, Natal (F. of S. A.).
Transvaal:—Magalisberg (Burke). Macamac (McLea). Pretoria, Aapie's Poort (Dr. Rehmann 4047). Malmanie Stream (Burtt-Davy 69). Selati Goldfields (Junod 1040).
Rhodesia:—Umtali and Mazoe (J. F. Darling; Holland; Mrs. Bennett).

64. *Pteris cretica*, Linn.
West, East, Kaffraria, Natal (F. of S. A.):—Engcobo (Flanagan 2721).
Orange River Colony:—Ficksburg (Quail).
Transvaal:—Magalisberg (Sanderson). Riet-vley, Belfast (Burtt-Davy 1237). Haenertsberg (Eastwood).
Rhodesia:—Umtali (Mrs. Bennett). Mazoe (Holland). Borrowdale, near Salisbury (H. M. Hole).
A tasselled form from Upper Umkomaas is in the Natal Government Herbarium.

65. *Pteris quadriaurita*, Retz.
Kaffraria:—Engcobo Mountain, 1896, 4,000 feet (H. G. Flanagan 2779).

Natal:—Frequent.

Transvaal:—Marovuni (Burtt-Davy 226). Magalisberg (Zeyher). Drakensberg, near Macamac Goldfields (J. H. McLea 41).

Rhodesia:—Victoria Falls (Richards). Near Salisbury (Holland). Umtali (Mrs. Bennett). Lo Magundi (J. F. Darling).

66. *Pteris flabellata*, Thun.

West, East, Kaffraria, Natal:—Common.

Transvaal:—Magalisberg (Zeyher; Burke; Sanderson). Zoutpansberg, 3,900 feet (Schlechter 4600).

Rhodesia:—Penhalanga (Holland). Umtali (Mrs. Bennett).

67. *Pteris Buchanani*, Baker.

West, East, Kaffraria, Natal (F. of S. A.).

68. *Pteris incisa*, Thun.

West, East, Natal (F. of S. A.).

69. *Pteris longipes*, D. Don.

This belongs to the section Tripartitæ, in which the lowest pinnæ are much larger than the others, often nearly equalling the central portion of the tripinnate frond. Baker states ("New Ferns, Annals of Botany," vol. v., 1891), "Further material shows *P. brevisora*, Baker, No. 39 (Synopsis Filicum), which has now been found in Zambesia, to be only a variety of this species, with shorter sori."

70. *Pteris aquilina*, Linn.

West, East, Kaffraria, Natal (F. of S. A.):—Umgazi River, Port St. John's (Flanagan 2606).

Orange River Colony:—Rouxville (Harper).

Transvaal:—Magalisberg (Sanderson). Athol and Barberton (Burtt-Davy 1899 and 256). Shilouvane (Junod 892).

Rhodesia:—Umtali (J. F. Darling). Salisbury, common (H. M. Hole). Near Mount Hampden, a quite glabrous variety (Holland).

71. *Lomaria inflexa*, Kunze.

Kaffraria and Natal (F. of S. A.).

72. *Lomaria attenuata*, Willd.

West, East, Kaffraria, Natal (F. of S. A.).

Transvaal:—Magalisberg (Sanderson; Bolus). Barberton (Burtt-Davy 327). Marovuni, Mamotsinri (Burtt-Davy 224). Haenertsberg (Eastwood).

Rhodesia:—Umtali (J. F. Darling; Mrs. Bennett).

73. *Lomaria punctulata*, Kunze.
   West, East, Kaffraria, Natal (F. of S. A.) :—George, 900 feet (Schlechter 2465).
   Var. *Atherstonei*, P. & R.
      East, Kaffraria, Natal (F. of S. A.).
   Var. *intermedia.*
      East and Natal (F. of S. A.).
   Var. *Krebsii.*
      East and Natal (F. of S. A.).

74. *Lomaria procera*, Sprengel.
   West, East, Kaffraria, and Natal (F. of S. A.).

75. *Lomaria Boryana*, Willd.
   West, East, Kaffraria, and Natal (F. of S. A.).
   Transvaal :—Mauchsberg to Falls (Burtt-Davy 485). Shilouvane (Junod 881). Marovuni (Burtt-Davy 234). Haenertsberg (Eastwood).
   Rhodesia :—Umtali (J. F. Darling; Mrs. Bennett).
   A form found at Patillos, Mid Illovo, Natal, has an auricle or single pinnule at the base of each pinna.

76. *Blechnum australe*, Linn.
   West, East, Kaffraria, Natal (F. of S. A.) :—Broughton, Molteno, 6,300 feet (Flanagan 1684).
   Orange River Colony :—Ficksburg (Quail).
   Transvaal :—Magalisberg (Sanderson). Marovuni (Burtt-Davy 221). Haenertsberg (Eastwood).

77. *Blechnum remotum*, Presl.
   Kaffraria (F. of S. A.).

78. *Asplenium Kraussii*, Moore.
   East, Kaffraria, Natal (F. of S. A.) :—Engcobo (Flanagan 2722).
   Transvaal :—(Lady Barkly).

79. *Asplenium Sandersoni*, Hk.
   Natal (F. of S. A.).
   Transvaal :—Houtbosch, 6,800 feet (Schlechter 4760).
   Rhodesia :—Umtali (Mrs. Bennett). Moramballa Mountains (Waller).

80. *Asplenium trichomanes*, Linn.
   West, East, Kaffraria, Natal (F. of S. A.) :—Broughton, Molteno (Flanagan 1677).
   Rhodesia :—Limestone caves at Sinoia, Lo Magundi, Hanyani River (H. M. Hole).

81. *Asplenium ebeneum*, Ait.
   East, Kaffraria, Natal (F. of S. A.).

82. *Asplenium monanthemum*, Linn.
  West, East, Kaffraria, Natal (F. of S. A.):—Broughton, Molteno, 6,300 feet (Flanagan 1678).
  Transvaal:—Haenertsberg (Eastwood).
  Rhodesia:—Umtali, not common (Mrs. Bennett).
  Specimens from Perie Forest show upper pinnæ Dareoid.

83. *Asplenium erectum*, Bory.
  Var. A. *lunulatum.*
    West, East, Kaffraria, Natal (F. of S. A.).
    Rhodesia:—Victoria Falls (Holland).
  Var. β. *minor.*
    Kaffraria (F. of S. A.).
  Var. C. *erectum.*
    West, East, Kaffraria, Natal (F. of S. A.).
    Transvaal:—Macamac (McLea). Haenertsberg (Eastwood).
    Rhodesia:—Umtali (Mrs. Bennett).
    A frond from Brown's bush, Toise River, has a bud on the stipe at the lowest pinnule.
  Var. D. *brachyotus.*
    Natal (F. of S. A.).
  Var. E. *Zeyheri.*
    East, Kaffraria, Natal (F. of S. A.).
  Var. F. *lobatum.*
    East, Kaffraria, Natal (F. of S. A.).
    Transvaal:—Houtboschberg, 6,000 feet (Schlechter 4466). Mamotsinri (Burtt-Davy 205). Haenertsberg (Eastwood).
    Rhodesia:—Umtali (Holland; Mrs. Bennett).

84. *Asplenium varians*, Hk. & Gr.
  East, Kaffraria, Natal (F. of S. A.).
  Rhodesia:—Umtali (J. F. Darling).

85. *Asplenium Gueinzianum*, Mett.
  Natal (F. of S. A.).

86. *Asplenium protensum*, Schrad.
  West, East, Kaffraria, Natal (F. of S. A.).
  Rhodesia:—Umtali (Holland; Mrs. Bennett).
  A. protensum, Schr.; var. *bipinnatifidum.*
  East and Kaffraria (F. of S. A.).

87. *Asplenium anisophyllum*, Kunze.
  East, Kaffraria, Natal (F. of S. A.).
  Transvaal:—Houtbosch (Dr. Rehmann 5589). Haenertsberg (Eastwood).
  Rhodesia:—Umtali (J. F. Darling; Mrs. Bennett).

88. *Asplenium prionitis*, Kunze.
    East, Kaffraria, Natal (F. of S. A.):—Port St. John's (Flanagan 2474).
89. *Asplenium serra*, L. & F.; var. *natalensis*.
    Natal (F. of S. A.).
90. *Aspleniun gemmiferum*, Schr.
    West, East, Kaffraria, Natal (F. of S. A.).
    Transvaal:—Marovuni (Burtt-Davy 228).
    Rhodesia:—Umtali (Holland; Mrs. Bennett).
    A. gemmiferum, Schr.; var. *flexuosum*.
    East and Kaffraria (F. of S. A.).
    Rhodesia:—Umtali (Mrs. Bennett).
    A. gemmiferum, Schr.; var. *discolor*.
    West, East, Kaffraria, Natal (F. of S. A.).
91. *Asplenium falcatum*, Lam.
    Frond coriaceous, glabrous, 12 inches long, 4–6 inches wide, simply pinnate; the pinnæ lobed one-third down and the lobes sharply toothed. Zambesiland (Synopsis Filicum).
92. *Asplenium pumilum*, Sw.
    Frond herbaceous, deltoid, 4–6 inches long and wide, sinuate above, bipinnate below; lower pinnæ most developed on the lower side. Zambesiland (Kirk).
93. *Asplenium Rawsoni*, Baker.
    West (F. of S. A.).
94. *Asplenium Adiantum-nigrum*, Linn.
    West, East, Kaffraria, Natal (F. of S. A.).
    Orange River Colony:—Ficksburg (W. A. Quail).
    Rhodesia:—Umtali (J. F. Darling).
95. *Asplenium solidum*, Kunze.
    West, East, Kaffraria, Natal (F. of S. A.).
96. *Asplenium cuneatum*, Lam.
    East, Kaffraria, Natal (F. of S. A.).
    Transvaal:—Marovuni (Burtt-Davy 217, 239).
    Var. B. *splendens*.
        East, Kaffraria, Natal (F. of S. A.).
    Var. C. *angustatum*.
        East (F. of S. A.).
97. *Asplenium furcatum*, Thun.
    (Baker now states that an earlier name is *A. præmorsum*, Sw.)
    West, East, Kaffraria, Natal (F. of S. A.):—George, 900 feet (Schlechter 2364).
    Transvaal:—Magalisberg (Sanderson). Mamotsinri (Burtt-

Davy 211). Crocodile and Magalies Rivers (Burtt-Davy 199). Haenertsberg (Eastwood).

Rhodesia :—Salisbury (J. F. Darling). Borrowdale (H. M. Hole). Umtali (Holland; Mrs. Bennett).

A. furcatum, Thun.; var. *tripinnatum*.

East, Kaffraria, Natal (F. of S. A.).

Transvaal :—Barberton Mountains (Burtt-Davy 330). Mamotsinri and Marovuni (Burtt-Davy 208, 216).

Rhodesia :—Umtali (J. F. Darling; Mrs. Bennett).

98. *Asplenium cicutarium*, Swartz.

Rhodesia :—Umtali (J. F. Darling; Mrs. Bennett).

Var. *Abyssinicum*, Fée.

Transvaal :—Magalisberg (Sanderson).

99. *Asplenium Mannii*, Hk.

A small, thinly herbaceous dareoid species, with deltoid-lanceolate fronds 1–2 inches long, the upper pinnæ simple, the lower dichotomously forked. Zambesia (Synopsis Filicum).

100. *Asplenium Dregeanum*, Kunze.

Kaffraria and Natal (F. of S. A.) :—Port St. John's, 1,200 feet (Flanagan 2472).

Rhodesia :—Umtali (Darling).

101. *Asplenium Thunbergii*, Kunze.

Natal (F. of S. A.).

(*Asplenium flaccidum*, Forst.; see F. of S. A.)

102. *Asplenium rutæfolium*, Kunze.

East, West, Kaffraria, Natal :—Frequent.

Transvaal :—Houtbosch (Dr. Rehmann 5584). Houtboschberg, 6,000 feet (Schlechter 4463). Marovuni (Burtt-Davy 237). Haenertsberg (Eastwood).

Rhodesia :—Umtali (Holland; Mrs. Bennett).

103. *Asplenium filix-fœmina*, Bernh.

Natal (F. of S. A.).

Rhodesia :—Penhalanga Forest (Mrs. Bennett). Umtali (Holland).

104. *Asplenium Schimperi*, A. Br.

Kaffraria :—Chumie (Mrs. Young).

Natal (F. of S. A.).

Rhodesia :—Salisbury (J. F. Darling).

105. *Asplenium aspidioides*, Schl.

East, Kaffraria, Natal (F. of S. A.).

Transvaal :—Haenertsberg (Eastwood).

Rhodesia :—Umtali (Darling; Holland).

(*Asplenium polypodioides*, Mett.; see F. of S. A.).

106. *Actiniopteris radiata*, Link.
Griqualand and Bechuanaland (F. of S. A.).
Transvaal:—Magalisberg (Burke & Zeyher 532; Todd; Zeyher No. 1874). Limpopo (H. M. Barber). Near Eureka City, Barberton (Dr. Vowel 1888).
Rhodesia:—Devil's Kantour, Tati (J. Fry 1887). Salisbury (Darling). Fairly common, Salisbury and Burrowdale (H. M. Hole). Umtali (Mrs. Bennett).

107. *Didymochlæna lunulata*, Desv.
Natal (F. of S. A.).
Rhodesia:—Umtali (Mrs. Bennett).

108. *Aspidium aculeatum*, Sw.; var. *pungens*.
East, West, Kaffraria, Natal:—Abundant everywhere.
Orange River Colony:—Ficksburg (Quail).
Rhodesia:—Umtali (Holland; Mrs. Bennett).

109. *Aspidium luctuosum*, Kunze.
East, Kaffraria, Natal (F. of S. A.):—Engcobo Mountain (Flanagan 2781).

110. *Aspidium capense*, Willd.
West, East, Kaffraria, Natal (F. of S. A.).

111. *Aspidium aristatum*, Sw.
Kaffraria and Natal (F. of S. A.).
Transvaal:—Macamac Gold Fields (J. H. McLea, No. 7).
Zambesia:—(*Fide* Kuhn, Filices Africanæ, 209.)

112. *Aspidium Macleaii*, Baker.
Kaffraria:—Bazija, Transkei (Rev. R. Baur; MacOwan).
Transvaal:—Wet kloofs, Pilgrim's Rest, Drakensberg (J. H. McLea, No. 34; Herb. Bolus 3030). Macamac (Ayres, Buchanan's List, No. 3, p. 30).

113. *Aspidium falcatum*, Sw.
East, Kaffraria, Natal (F. of S. A.):—Chenkwe Mountain, near Umtata, 4,000 feet (Flanagan 2648).
Transvaal:—Macamac (McLea, No. 6).

114. *Nephrodium patens*, Desv.
Differs from the common *N. Bergianum* in the lower pinnæ being not reduced. Zambesiland (Synopsis Filicum 262).

115. *Nephrodium albo-punctatum*, Desv.
Natal (F. of S. A.).
Rhodesia:—Borrowdale (H. M. Hole). Salisbury (Holland; Darling). Umtali (Mrs. Bennett, who states that it is scented).
(Baker now states that its oldest name is *Polypodium pectinatum*, Forsk.)

116. *Nephrodium Zambesiacum*, Baker ("New Ferns," p. 58).

Fronds bipinnate, large, somewhat hairy. Lower pinnæ not reduced, 12 inches long, 1¼ inches wide. Segments distinct, narrow, entire. Veinlets numerous, simple.

Zambesi highlands (Buchanan).

117. *Nephrodium Bergianum*, Bkr.

East, West, Kaffraria, Natal:—Abundant.

Transvaal:—Elim (Dr. Hans Schinz). Shilouvane (Junod 650).

Rhodesia:—Umtali (J. F. Darling). Penhalanga (Mrs. Bennett; Holland). Victoria Falls (Richards).

118. *Nephrodium mauritianum*, Fée.

Kaffraria and Natal (F. of S. A.).

Rhodesia:—Lo Magundi (J. F. Darling). Mazoe and Victoria Falls (Holland).

119. *Nephrodium molle*, Desv.

Kaffraria and Natal (F. of S. A.).

Transvaal (Buchanan; Lady Barkly).

Rhodesia:—Matabeleland (Oates). Zambesia (Kirk).

120. *Nephrodium unitum*, R. Br.

West, East, Kaffraria, Natal (F. of S. A.).

Rhodesia:—Small island on the Zambesi (Holland). Zambesi and Luabo Rivers (Kirk).

N. unitum, R. Br.; var. *propinquum*.

Zambesi northward.

121. *Nephrodium thelypteris*, Desv.

West, East, Kaffraria, Natal (F. of S. A.).

Rhodesia:—Mazoe and Umtali (J. F. Darling). Penhalanga (Holland). Umtali (Mrs. Bennett).

122. *Nephrodium filix-mas*, Rich.; var. *elongatum*.

West, East, Kaffraria, Natal (F. of S. A.):—Broughton, Molteno (Flanagan 1682).

Orange River Colony:—Ficksburg (Quail).

Transvaal:—Macamac (McLea). Marovuni (Burtt-Davy 227).

Rhodesia:—Umtali and Lo Mogundi, 9 feet high (Darling). Umtali (Mrs. Bennett).

Without having seen the forms connecting this with the normal *N. filix-mas* I cannot say that it does not belong there, but as a South African fern it belongs to a different group—that of *N. spinulosum*—and I consider the name *N. elongatum*, Hk. & Gr., ought to be restored.

123. *Nephrodium inæquale*, Hk.
West, East, Kaffraria, Natal (F. of S. A.).
Rhodesia :—Lo Magundi (Darling). Umtali (Holland). Moramballa Mountains (Kirk).

124. *Nephrodium athamanticum*, Hk.
Kaffraria and Natal (F. of S. A.).
Transvaal :—Macamac (McLea). Magalisbergen (Sanderson). Shilouvane (Junod 896). Marovuni, rare (Burtt-Davy 219). Belfast (Burtt-Davy 1987).
Rhodesia :—Near the Jumbo Mine (Holland). Umtali (Mrs. Bennett).

125. *Nephrodium Buchanani*, Baker.
Kaffraria and Natal (F. of S. A.) :—Chumie, Kaffraria (Mrs. Young).
Transvaal :—Pilgrim's Rest (J. H. McLea). Haenertsberg (Eastwood).

126. *Nephrodium catopteron*, Hk.
West, Kaffraria, Natal (F. of S. A.).
Rhodesia :—Near Umtali, June, 1904 (Mrs. Bennett; Holland).

127. *Nephrodium Lastii*, Baker (" New Ferns," p. 64).
Fronds large, herbaceous, decompound, glabrous. Lower pinnæ a foot long, oblong-lanceolate; pinnules lanceolate, segments $\frac{1}{4}$ inch wide, cut into oblong toothed lobes.
Zambesia :—Namuli Mukua Country (J. T. Last).

128. *Nephrodium crenatum*, Sim.
Transvaal (Bolus). Macamac (Ayres).

129. *Nephrodium cicutarium*, Baker.
Rhodesia :—Moramballa Mountains (Kirk; Waller). Umtali (Darling; Holland; Mrs. Bennett).

130. *Nephrolepis cordifolia*, Presl. (= *N. tuberosa*, Hk.).
Crown suberect, with numerous long, wiry, or in places tuberous runners, from which new plants arise. Frond 1–4 feet long, $1\frac{1}{2}$–2 inches wide, mostly of equal width, glabrous except the rachis which has numerous white scales when young which become brown with age if persistent. Pinnæ close, simple, one-third inch wide, 1–$1\frac{1}{2}$ inches long, slightly crenate, cordate at the base, auricled or lobed on the upper side at the base, the auricles overlapping on the under side of the rachis. Sori half-way between the midrib and the edge. Said by Baker to differ from *N. exaltata* by its narrower frond, close blunt pinnæ and submedial sori.

Rhodesia:—Umtali (J. F. Darling 20). Victoria Falls (Richards; Holland). Matabeleland (Oates).

131. *Nephrolepis exaltata*, Schott.

The difference between this and *N. cordifolia* are mentioned under that species, but I fail to distinguish the two as species either in the few wild specimens or in cultivation in Natal. Several cultural forms are in cultivation, and it seems not improbable that the specimen in Natal Government Herbarium, No. 7581, from Lower Umzimkulu, collected by Dr. Dimock Brown in 1897, was from an escape, as no one else has found it in Natal. Baker, however, includes both *N. cordifolia* and *N. exaltata* among the plants collected by Oates in Matabeleland.

132. *Nephrolepis biserrata*, Schott.

Natal (F. of S. A.).

133. *Oleandra articulata*, Cav.

Kaffraria:—Port St. John's, 1896, 100 feet (H. G. Flanagan 2471).

Natal (F. of S. A.).

Transvaal:—Magalisberg (Zeyher; Burke 530).

134. *Polypodium proliferum*, Presl.

Natal (F. of S. A.).

Rhodesia:—Hunyani River, 1894 (J. F. Darling). Banks of Mazoe (Holland). Umtali (Mrs. Bennett), with a frond 4 feet long, 6 inches wide below, but the upper half with rather distant short alternate pinnules 1 inch long, ½ inch wide. Nine axils have buds, some developed into fronds 1 foot long. Mrs. Bennett writes that it is a lovely drooping fern, and most effective in hanging baskets.

135. *Polypodium unitum*, Hk.

Natal (F. of S. A.).

Rhodesia:—Umtali (Mrs. Bennett).

136. *Polypodium parvulum*, Bory.

Fronds subcoriaceous, ultimately naked, pinnate, 4–6 inches long, ½ inch wide; pinnæ 1 line wide. Sori 2–6 to a pinna, medial.

Zambesiland (Synopsis Filicum).

137. *Polypodium vulgare*, Linn.

West, East, Kaffraria, Natal (F. of S. A.).

138. *Polypodium ensiforme*, Thun.

West, East, Natal (F. of S. A.).

139. *Polypodium incanum*, Swartz.
West, East, Kaffraria, Natal (F. of S. A.):—Engcobo (Flanagan 2716).
Transvaal:—Macamac (McLea). Everywhere, Marovuni (Burtt-Davy 218).
Rhodesia:—On a tree in the temple of Zimbabye, June, 1904 (Holland). Mount Moramballa (Kirk).

140. *Polypodium phymatodes*, Linn.
Natal (F. of S. A.).
Rhodesia:—Umtali (Mrs. Bennett). Zambesia (Kirk).

141. *Polypodium lineare*, Thun.
Kaffraria and Natal (F. of S. A.).
Polypodium lineare, Th.; var. *Schraderi.*
West, East, Kaffraria, Natal (F. of S. A.).
Transvaal:—Marovuni (Burtt-Davy 288).

142. *Polypodium normale*, Don.
Natal (F. of S. A.).
Rhodesia:—Umtali (Mrs. Bennett).

143. *Polypodium lanceolatum*, Linn.
West, East, Kaffraria, Natal (F. of S. A.).
Transvaal:—Marovuni (Burtt-Davy 230). Embabaam, Swaziland (Burtt-Davy 2796).
Rhodesia:—Umtali (Mrs. Bennett). Moramballa Mountains (Kirk; Waller).
P. lanceolatum, Linn.; var. *sinuatum.*
This appears from description to correspond with the Columbian *P. leucosporum*, Klot.; see Baker's "New Ferns," p. 94.
East, Kaffraria, Natal (F. of S. A.).
Transvaal:—Houtboschberg, 6,300 feet (Schlechter 4452).

144. *Polypodium lycopodioides*, Linn.
Natal (F. of S. A.).
P. lycopodioides, Linn.; var. *Mackenii*, Bkr.
Natal (F. of S. A.).

145. *Polypodium fissum*, Baker.
From description this appears to me to be too near *P. africanum*, the main difference being that this has ferruginous tomentum on the under surface of the frond, while that of *P. africanum* is said to be nearly white. But, as mentioned in "Ferns of South Africa," that of *P. africanum* is at first rufous and afterwards nearly white, at least in some localities.
Baker includes *P. fissum* from Zambesi highlands ("New Ferns," p. 90).

146. *Polypodium africanum*, Mett.
Kaffraria and Natal (F. of S. A.).
Rhodesia :—Umtali (Holland ; Mrs. Bennett).

147. *Polypodium irioides*, Lam.
Kaffraria and Natal (F. of S. A.) :—Port St. John's (Flanagan 2469).
Rhodesia :—Near Massi Kessi (Holland). Zambesiland (Kirk). Umtali (Mrs. Bennett).

148. *Nothochlæna Rawsoni*, Pappe.
West (F. of S. A.)

149. *Nothochlæna inæqualis*, Kunze.
Natal (F. of S. A.).
Transvaal :—Magalisberg (Burke ; Zeyher). Marovuni (Burtt-Davy 238). Near Standerton (Rehmann 6739).
Rhodesia :—Salisbury (J. F. Darling). Under granite rocks near Salisbury (Holland).

150. *Nothochlæna Buchanani*, Baker.
Kaffraria :—Port St. John's, 1896 (Flanagan 2580). Toise River (Dr. Brownlee).
Natal (F. of S. A.).
Transvaal :—Marovuni (Burtt-Davy 225).

151. *Nothochlæna Eckloniana*, Kunze.
West, East, Kaffraria, Natal (F. of S. A.).
Orange River Colony :—Ficksburg (Quail).
Transvaal :—Magalisberg (Burke). Trigardsfontein (Dr. Rehmann). Houtboschberg, 6,800 feet (Schlechter 4704).

152. *Gymnogramme totta*, Schl.
West, East, Kaffraria, Natal (F. of S. A.).

153. *Gymnogramme cordata*, Schl.
West, East, Kaffraria, Natal (F. of S. A.).
Orange River Colony :—Hebron (Flanagan 1675).
Transvaal :—Magalisberg (Burke). Crocodile and Magalies Rivers (Burtt-Davy 208).
Rhodesia :—Lo Magundi and Fort Salisbury (J. F. Darling).

G. cordata, Schl. ; var. *namaquensis*.
North-West (F. of S. A.).
Rhodesia :—Common round Salisbury (H. M. Hole).

G. cordata, Schl. ; var. *bipinnata*.
West (F. of S. A.).

154. *Gymnogramme leptophylla*, Desv.
West (F. of S. A.).

155. *Gymnogramme ochracea*, Presl.
Natal (F. of S. A.).
Transvaal (Herb. Bolus).
156. *Gymnogramme argentea*, Mett.
Natal (F. of S. A.).
Transvaal :—Drakensberg, near Macamac Goldfields (McLea).
G. argentea, Mett.; var. *aurea*.
Natal (F. of S. A.).
Orange River Colony (Buchanan).
Transvaal :—Magalisberg (J. H. McLea).
157. *Gymnogramme lanceolata*, Hk.
Kaffraria and Natal (F. of S. A.).
Transvaal :—(McLea). Marovuni (Burtt-Davy 280).
Rhodesia :—Umtali (Mrs. Bennett).
158. *Vittaria lineata*, Sw.
West, East, Kaffraria, Natal (F. of S. A.).
Rhodesia :—Zambesiland (Synopsis Filicum).
(*Monogramme graminea*, Schk.; see "Ferns of South Africa.")
159. *Acrostichum conforme*, Sw.
West (F. of S. A.).
160. *Acrostichum latifolium*, Swartz.
Natal (F. of S. A.).
Rhodesia :—Umtali (Mrs. Bennett).
161. *Acrostichum viscosum*, Swartz.
West, East, Kaffraria, Natal (F. of S. A.).
Transvaal :—Pilgrim's Rest (J. H. McLea 54; Bolus 1730). Marovuni, rare (Davy 290). Haenertsberg (Eastwood).
A. viscosum, Sw.; var. *rupestre*.
West and Kaffraria (F. of S. A.).
Transvaal :—Pilgrim's Rest (J. H. McLea).
162. *Acrostichum hybridum*, Bory.
West, Kaffraria, Natal (F. of S. A.).
163. *Acrostichum Aubertii*, Desv.
Natal (F. of S. A.).
Rhodesia :—Mount Zomba, Zambesia (Kirk).
164. *Acrostichum spathulatum*, Bory.
Natal (F. of S. A.).
165. *Acrostichum tenuifolium*, Baker.
Kaffraria and Natal (F. of S. A.).
166. *Acrostichum punctulatum*, Sw.

Fronds pinnate, dimorphous, the fertile being similar to but much smaller than the barren. Barren frond 1–2 feet long, up to 12 inches wide, with a terminal pinna and on each side 1 to 8 lateral pinnæ. Pinnæ lanceolate, 4–9 inches long, 1–2 inches wide; edges entire; veins anastomosing copiously.

Zambesiland (Synopsis Filicum).

167. *Acrostichum Heudelotii*, Hk.

Fronds subcoriaceous, pinnate; the pinnæ of the fertile frond narrower than those of the barren. Fronds 1–2 feet long, 6–9 inches wide; pinnæ numerous, sessile, entire, ½–¾ inch wide; veins anastomosing, indistinct.

Zambesiland:—Manganja (Kirk).

168. *Acrostichum aureum*, Linn.

East and Natal (F. of S. A.).

Transvaal:—Near Magalisberg (Sanderson).

Zambesia (Kirk).

Genus XXX. *β. Platycerium*, Desv. Plant epiphytal, the barren fronds few, flat and thalloid, and adpressed to what the plant grows on, rounded or cordate at the base, the fertile fronds rising from the sinus, and fresh plants starting from roots at the margin of the mature barren frond. Fertile fronds simple or dichotomously branched, bearing the sori in patches on the back of the bifurcations. Veins anastomosing more or less in the fertile frond, and freely in the barren frond. South-east Asia and Australia, Tropical Africa and South America.

169. *Platycerium alcicorne*, Desv.

Barren fronds few, 3–9 inches wide, rounded, conspicuously veined, those from overlapping plants forming a large thalloid mass 1–3 feet in diameter. Fertile fronds several together, ascending, 2 feet long, up to 3 times dichotomously branched, leathery, glabrous above, white pubescent below. Ultimate segments ½–1 inch wide, 4–8 inches long, rounded at the point. Sori in brown woolly masses on the lower surfaces of the ultimate segments, or meeting and extending downward where they unite. On immature plants less-divided or simple fertile fronds without sori occur. *P. alcicorne* is recorded from Australia, Mascarenes, Seychelles, and South America.

Rhodesia:—Near Massi-Kessi (Holland). Umtali (Mrs. Bennett). Miss Schultz brought plants from Umtali which are now growing in the Natal Botanic Garden, Durban, as also are several allied forms from Madagascar.

170. *Todea barbara*, Moore.
West, East, Natal (F. of S. A.).
Transvaal :—Kloof of Mamotsinri (Burtt-Davy 203).

171. *Osmunda regalis*, Linn.
West, East, Kaffraria, Natal (F. of S. A.) :—Engcobo (Flanagan 2477).
Transvaal :—Pilgrim's Rest (W. Roe; Bolus 1732). Shilouvane (Junod 516). Not common, kloofs of mountains (Burtt-Davy 206).
Rhodesia :—Mazoe (H. M. Hole). Umtali (J. F. Darling; Mrs. Bennett). Mr. Edmond's farm near Salisbury (Holland).

172. *Schizæa tenella*, Kaulf.
West, East, Kaffraria, Natal (F. of S. A., except delete *Wood*) :—Engcobo Mountain, 1896 (Flanagan 2755).

173. *Schizæa pectinata*, Smith.
West, East, Natal (F. of S. A.) :—Near Umbilo Falls (Wood).
Kaffraria :—Port St. John's, 1896 (Flanagan 2529).

174. *Anejmia tomentosa*, Sw.
Natal (F. of S. A.).
Transvaal :—Mr. J. M. Wood has had specimens from Swaziland.

175. *Aneimia anthriscifolia*, Schrad.
Stipe 6 inches long, bearing when fertile 1 barren and 2 fertile divisions. On fertile fronds the barren segment is firmly herbaceous, deltoid, 5–6 inches long, 4–5 inches wide, 3-pinnate or 3-pinnatifid, somewhat fibrillosé from long white hairs; ultimate segments toothed; fertile divisions erect, rigid, ½ inch wide, 6 inches long on 3-inch stalks, somewhat tomentose, 3–4-pinnate, the segments narrow, incurved over the sori. Barren fronds rather larger than the barren section of the fertile frond.
This is included by Baker as a form of *A. tomentosa*, and considering the latter as a widely distributed and variable species it may be so, but so far as local specimens go this is sufficiently distinct to rank as a species here.
Transvaal :—Barberton (J. M. Wood 7599).
Rhodesia :—Near Umtali (Holland; Mrs. Bennett).

176. *Aneimia Dregeana*, Kunze.
Kaffraria and Natal (F. of S. A.).
Transvaal :—Marovuni (Burtt-Davy 222).

177. *Mohria caffrorum*, Desv.

West, East, Kaffraria, Natal:—Common (F. of S. A.).

Orange River Colony:—Ficksburg (Quail).

Transvaal:—Magalisberg (Zeyher). Near Johannesburg (D. Crawford). Riet-vlei, Belfast, Barberton, Marovuni (Burtt-Davy 1936, 328, and 232).

Rhodesia:—Umtali (Darling; Mrs. Bennett). Matabeleland (Oates). Zambesi highlands (Baker, New Ferns, 115).

178. *Mohria lepigera*, Baker. (*Nothochlæna lepigera*, Baker, Jour. Bot., 1884, 53.)

Zambesia:—Mount Dzomba, altitude 6,000–7,000 feet (Sir J. Kirk).

Genus XXXV. β. *Lygodium*, Sw. Stems slender, scandent, bearing alternate fronds, which by being dichotomous near the base appear like two opposite fronds. Capsules in spikes along the edges of ordinary or modified fronds or part fronds, each capsule separately in the axil of an almost marginal infolded involucre, the involucre of each capsule imbricating over that next above.

Widely diffused through Asia, America, Africa, and Australasia.

L. scandens:—Each pinna simply pinnate.

L. Kerstenii.:—Each pinna 2-pinnate or more divided.

179. *Lygodium scandens*, Sw.

Underground stem long, black, wiry, slender, repeatedly branched, rooted abundantly and clothed with shining black lanceolate scales. Scandent stems slender, hard, wiry, glabrous, unbranched, many feet in length, and producing alternate glabrous fronds, 3–6 inches apart. Primary petiole 2 lines long, ending in an abortive scaly bud, and bearing two divaricate pinnæ, each 3–6 inches long and simply pinnate. Pinnules jointed on to the short petioles, variable in form, 1–1½ inches long, ½–1 inch wide below, rounded, cordate, or lobed at the base, and tapering to the rounded apex. Margin crenulate, and in the fertile fronds bearing several irregular segments 1–6 lines long, 1–3 lines wide, several or all of which are modified into capsule-bearing spikes. Terminal pinnule usually forked. This species, which occurs in Eastern Asia, Eastern Australia, Australasia, and Tropical Africa, has several forms; our plant differs considerably from the form most common in cultivation.

Natal:—Zululand, R. D. Lyle, January, 1899 (Wood 7335, Natal Government Herbarium 7982 and 7752). Maputa, Amatongaland (Forester Schof. 1902).

180. *Lygodium Kerstenii*, Kuhn. (=*L. subulatum*, Bojer).

Stem wiry, scandent. Frond glabrous, dichotomously branched at the base, each pinna bipinnate or more divided; pinnules not articulated, 1–3 inches long, crenate, lobed along the margin, 3-fid or with large lobes at the base. Lower pinnules 3–5-lobed, the central lobe largest. Fertile fronds scarcely different from the barren, except that they bear the short narrow spikes all along the margin.

Madagascar and East Africa.

Rhodesia:—Mr. Holland's specimens from Waterfall at Penhalanga are the barren base-fronds from non-climbing stems, and consequently, as occurs throughout the genus, larger and more flabellate than those which occur on the climbing stems. Mrs. Bennett also sends from Umtali similar specimens which she states have not got beyond that state during three years' cultivation, but she also sends beautiful scandent specimens, fully fertile, from the natural habitat.

181. *Marattia fraxinea*, Smith.

West, East, Kaffraria, Natal (F. of S. A.):—Insinuka, Port St. John's, with lobed pinnules (Flanagan 2476).

Transvaal:—Drakensberg (McLea). Marovuni (Burtt-Davy 233). Haenertsberg (Eastwood).

Rhodesia:—Umtali (J. F. Darling; Mrs. Bennett). Penhalanga (Holland).

182. *Ophioglossum Bergianum*, Schl.

R. Schlechter, who collected this in 1892 in several localities near Cape Town, distributed specimens, considering that his 989 was typical *O. Bergianum*, Schl., and that his 1017 and 1058 were a variety of the same, which he named var. *Harveyanum.* The latter, however, are Schlechtendal's *O. Bergianum*, as figured in Hooker's "Icones Plantarum," Plate 263, and by me in "Ferns of South Africa," Plate 143, and corresponds with Harvey's and Pappe's specimens. The name var. *Harveyanum* must therefore sink. These specimens are from Table Mountain, above Orange Kloof, 700 to 1,200 feet altitude, and from moist sandy ground near Wynberg, 80 feet altitude, and Schlechter's 10843 collected at Lammkraal, Clanwilliam, in 1897, also belongs to this.

183. *Ophioglossum lusitanicum*, Linn.

Schlechter's 989, mentioned above, does not, however, belong to *O. Bergianum*, the barren and fertile fronds being united at the base, and the barren frond wider than in that species. It belongs to *O. lusitanicum*, L., being one of its smaller varieties. Fertile frond ¾–1½ inches high, including the spike, which is ⅓ inch long, with about 6 pairs of capsules, and surmounted by a flattened leafy point. Barren frond rising from the fertile above the base, shortly petioled, ½–¾ inch long, 2 lines wide, linear-lanceolate. Roots few, fleshy; rootstock not descending. Mediterranean, West Africa, India, Australia, and New Zealand; probably often overlooked.

Western Province:—Constantiaberg, near Hout Bay, altitude 250 feet (Schlechter 989).

184. *Ophioglossum nudicaule*, Linn. f.

Rootstock descending, fleshy; roots numerous. Fronds several, the barren segment ovate, ¾–1 inch long, ½ inch wide, shortly stalked, rising from the lower portion of the fertile peduncle which is 1–1½ inches long, slender, and bearing a ⅓-inch spike of 6–7 pairs of capsules surmounted by a small acute point.

Differs from *O. vulgatum* in its small size, in having the fertile and sterile segments united near the base, and in the barren segment being more distinctly stalked.

O. nudicaule, L. fil.; *O. capense*, Schl.; var. β. *nudicaule*, Schl. Adumb. 9.

Widely distributed in America, Australia, Asia, and Africa.

Western Province:—Lammkraal, Clanwilliam, 1,000 feet, August, 1897 (R. Schlechter 10842).

185. *Ophioglossum vulgatum*, Linn.

West, East, Kaffraria, and Natal (F. of S. A.).

Transvaal:—Magalisberg (Burke).

186. *Ophioglossum reticulatum*, Linn.

Natal (F. of S. A.).

Rhodesia:—Zambesiland (Kirk).

FERN ALLIES.

187. *Equisetum ramosissimum*, Desv.

West, East, Kaffraria, Natal (F. of S. A.):—Centocow, Natal (T. R. Sim).

Transvaal:—Many localities (J. Burtt-Davy).

Rhodesia:—Zambesi (Kirk).

188. *Lycopodium saururus*, Linn.
    West and Natal (F. of S. A.).

189. *Lycopodium verticillatum*, Linn.
    Kaffraria and Natal (F. of S. A.).
    Transvaal:—Macamac (McLea 31). Houtbosch 6,800 feet (Schlechter 4757).
    Rhodesia:—Umtali (Holland).

190. *Lycopodium gnidioides*, Linn.
    West, East, Kaffraria, Natal (F. of S. A.).
    Transvaal:—Macamac (McLea). Houtbosch, 6,800 feet (Schlechter 4758).

191. *Lycopodium dacrydioides*, Baker.
    Closely allied to *L. gnidioides*, and not known to me, but from description appears to have simple instead of forked spikes, narrower and longer leaves, up to ¾ inch long, and rather longer bracts than that species.
    "Mountains of Transvaal, Natal, Zambesiland, Cameroons, Fernando Po, and St. Thomas" (Baker, "Fern Allies," p. 18).

192. *Lycopodium cernuum*, Linn.
    West, East, Kaffraria, and Natal (F. of S. A.):—Hilton Road, Natal (T. R. Sim).

193. *Lycopodium clavatum*, Linn.
    West, East, Kaffraria, and Natal (F. of S. A.):—Sweetwaters, Natal (T. R. Sim).
    Transvaal:—Macamac (McLea). Sabie Falls to Pilgrim's Rest (Burtt-Davy 432). Barberton (Burtt-Davy 558).

194. *Lycopodium carolinianum*, Linn.
    West, East, Kaffraria, and Natal (F. of S. A.).
    Transvaal:—Magalisberg (Burke).

195. *Psilotum triquetrum*, Swartz.
    Natal (F. of S. A.):—Near Murchison, Alfred Co. (Wood 2429).

196. *Selaginella pumila*, Spring.
    West and Natal (F. of S. A.).

197. *Selaginella rupestris*, Spring.
    East, Kaffraria, Natal (F. of S. A.).
    Orange River Colony:—Ficksburg (Quail).
    Transvaal:—Houtbosch (Dr. Rehmann 5576). Marovuni, Crocodile and Magalies Rivers, and Forbes Reef, Swaziland (Burtt-Davy 14, 199, 2794).
    Rhodesia:—Near Tette, Zambesia (Peters).

198. *Selaginella depressa*, A. Br.

This is now found to be not uncommon in Natal, growing alike on the exposed rock surfaces on the top of the Zwartkop and on the damp rocks around waterfalls and forest streams.

Cape (Thunberg; Menzies).

Kaffraria:—Mount Fletcher (T. R. Sim).

Natal (McKen):—Inanda and Town Hill (Natal Government Herbarium). Zwartkop (Stayner). Sweetwaters, Bulwer, &c. (T. R. Sim).

199. *Selaginella Kraussiana*, A. Br.

East, Kaffraria, and Natal (F. of S. A.).

Transvaal:—Pilgrim's Rest (McLea).

Rhodesia:—Umtali, 1892 (J. F. Darling).

200. *Selaginella integerrima*, Spring.

Transvaal:—Magalisberg (Sanderson; see F. of S. A.).

201. *Selaginella tectissima*, Baker.

Transvaal:—Magalisberg (Sanderson).

202. *Selaginella Cooperi*, Baker.

Orange River Colony (Cooper 1056).

203. *Selaginella Mackenii*, Baker.

Natal (F. of S. A.).

204. *Selaginella imbricata*, Spring.

Zambesiland (Baker, "Fern Allies," p. 87).

205. *Selaginella* (species).

This is mentioned in "Ferns of South Africa," p. 262. Since then Mrs. Bennett has sent in the same species from the same district—Umtali—but unfortunately not yet in condition for identification.

206. *Azolla pinnata*, R. Br.

Cape and Natal (F. of S. A.).

207. *Isoetes natalensis*, Baker.

Natal (F. of S. A.).

208. *Isoetes Wormaldii*, Sim (New Species), Pl. V.

Rootstock 3-lobed; leaves 50 to 70, ligulate-terete or somewhat flattened, 9–18 inches long, 1 line diam., hardly narrowed to the rounded point, flaccid, rising to the surface, then floating. No stomata on the submerged parts; floating parts dark green and grass-like. Veins one central and one marginal on each side throughout. Membranous leaf-base dilated and its margins enclosing and half-covering the sporange, which is axillary, usually produced in the axil of every leaf, $\frac{1}{3}$ inch long,

⅛ inch wide, membranous, containing numerous macrospores or microspores. Microspores white, 3-ridged, tubercular.

In ponds around East London, and in the Victoria Park, East London. First found by Mr. W. H, Wormald, December, 1893 (T. R. Sim 1567).

209. *Marsilia Burchellii*, A. Br.

"Cape Colony as far north as the Transvaal" (Baker, "Fern Allies," 144).

210. *Marsilia biloba*, Willd.

East (F. of S. A.).

211. *Marsilia capensis*, A. Br.

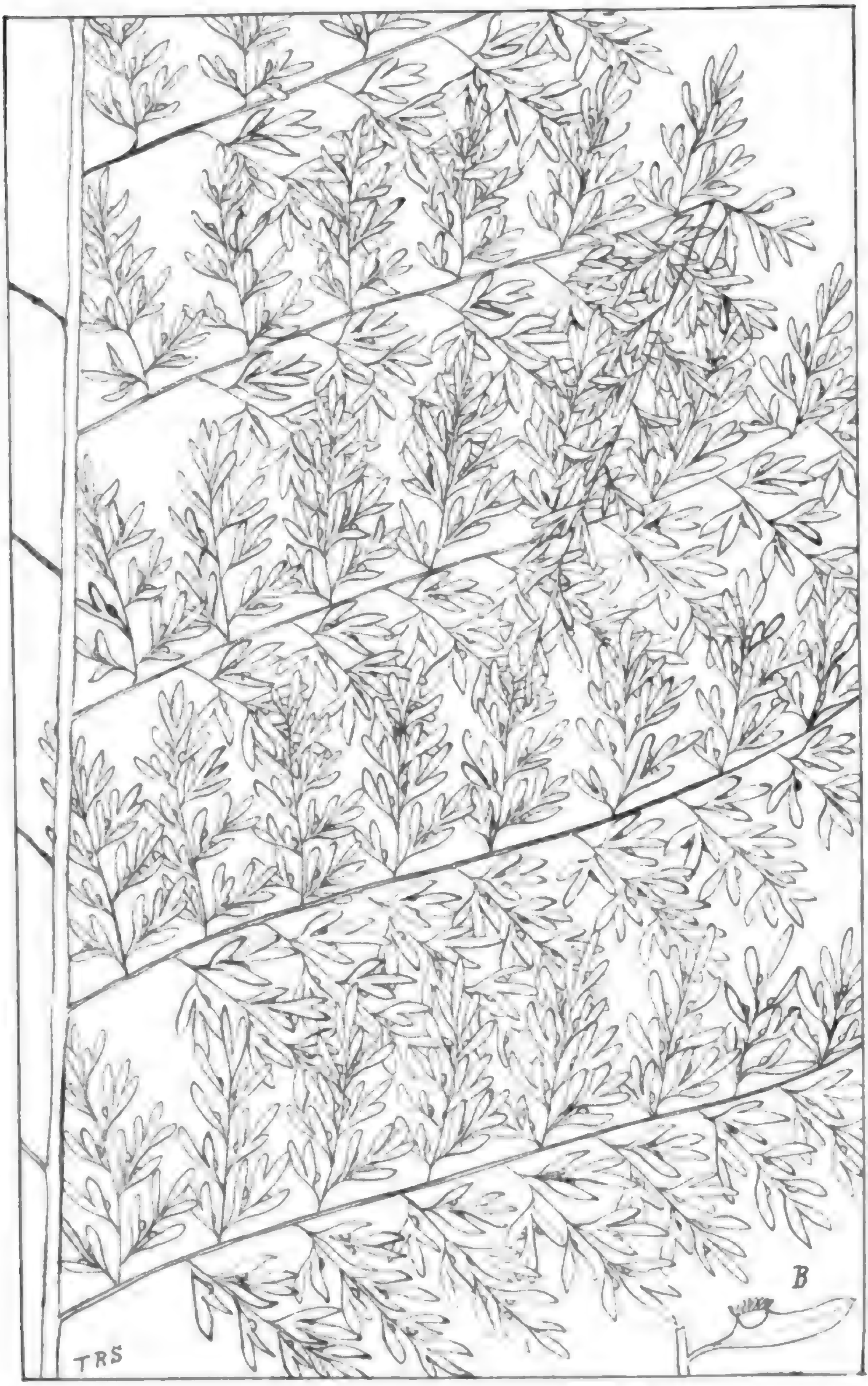
West, East, Kaffraria, Natal (F. of S. A.).

212. *Marsilia macropoda*, Presl.

Cape, Kaffraria, and Natal (F. of S. A.).

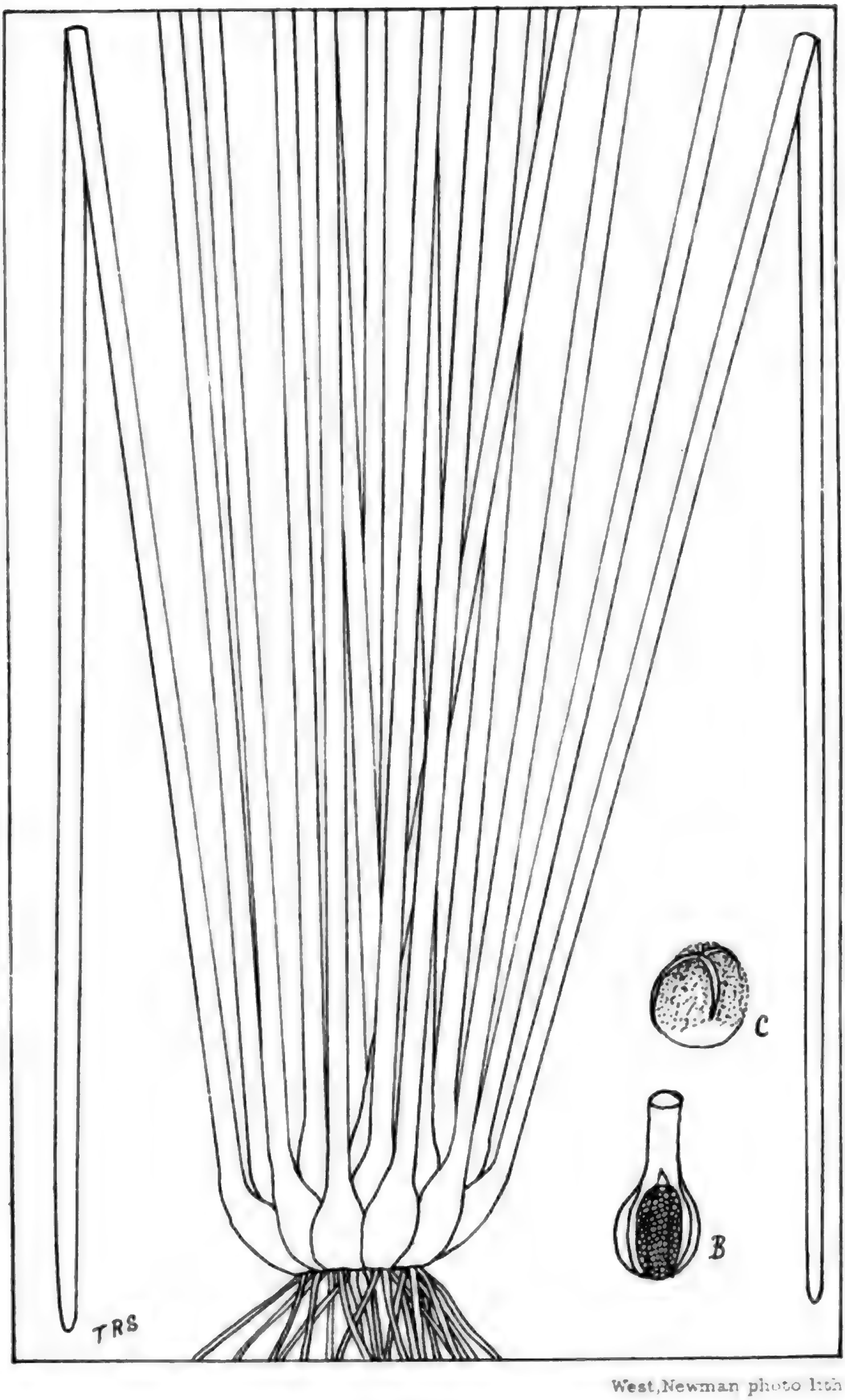
Transvaal:—Pretoria (Dr. Rehmann). Mooi River ditches at Potchefstroom (Burtt-Davy 1027).

Variety, Springbokflats, common in vleys (Burtt-Davy 1746).



West, Newman photo lith

DAVALLIA HOLLANDII, *SIM.*
B. Fertile segment.



West, Newman photo lith

ISŒTES WORMALDII, *SIM*.
B. Sporange, natural size. C. Macrospore, much magnified.

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ON THE NATURE OF THE EFFECT OF THE SUN-SPOT FREQUENCY ON THE VARIATION OF THE MAGNETIC ELEMENTS AT THE CAPE OF GOOD HOPE.

By G. H. H. Fincham, M.A.

(Read March 28, 1906.)

§ 1. The relationship existing between the Sun-spot Frequency and the variation of the various elements of Terrestrial Magnetism has of late been much discussed. So far, however, no results for the Cape of Good Hope have been published; the following is an account of some of these and of how they have been obtained. The observations upon which this investigation is based are those taken by a detachment of the Royal Artillery during the period 1842–1846, both inclusive, and published by Sabine in a series of volumes entitled "Magnetical and Meteorological Observations," a copy of which is to be found at the Royal Observatory (Cape).

§ 2. *Declination.*

Sabine gives a table of figures representing in Scale Divisions the mean hourly position of the magnet of the Declinometer for the period 1842–1846. Wolf's formula for associating magnetic quantities with Sun-spot Frequency is—

$$\Delta = \Delta' + r\Delta''$$

where r = Sun-spot Frequency.

In applying Wolf's formula to the above observations Δ is taken as the excess of the hourly mean over the monthly mean in minutes of arc (one sc. div. = ·751′).

Knowing the daily inequality of the Declination and the various values of *r* we can determine the most probable values of the quantities Δ′D and Δ″D for any particular hour by applying the principle of least squares and solving the resultant normal equations.

Table of Sun-spot Frequencies.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
1842	·2	·22	·22	·27	·25	·21	·13	·27	·19	·38	·41	·18
1843	·13	·04	·08	·08	·21	·11	·10	·12	·04	·05	·19	·13
1844	·09	·15	·14	·21	·12	·04	·21	·24	·07	·22	·11	·22
1845	·26	·44	·43	·57	·48	·31	·31	·32	·30	·41	·39	·60
1846	·39	·51	·64	·69	·60	·65	·47	·55	1·07	·56	·60	·66

The results obtained by solving the various equations are given in Tables II. and III. Table I. contains the mean daily inequality for the period considered.

TABLE I.

ΔD.

Cape of Good Hope Hours (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon +34 min.												
0	·82	·20	·52	·64	— ·60	— ·83	—1·18	—1·99	—1·08	1·34	·62	·88
1	1·52	2·02	1·73	1·51	·07	— ·22	— ·51	—1·04	— ·06	2·23	1·62	1·79
2	1·91	2·96	2·35	1·39	·41	·25	·26	·19	·39	2·21	1·98	1·74
3	1·33	2·61	1·96	1·04	·50	·25	·45	·65	·53	1·62	1·72	1·21
4	1·01	1·67	1·09	·76	·16	— ·15	— ·95	·37	·33	·57	1·19	·76
5	·78	·95	·66	·42	·25	— ·53	— ·58	— ·34	·07	·10	·77	·63
6	·56	·59	·58	·18	— ·12	— ·47	— ·55	— ·28	·03	·33	·83	·58
7	·78	·90	·71	·36	— ·06	— ·53	— ·66	— ·14	·16	·63	1·24	·93
8	1·06	·86	·68	·34	— ·07	— ·32	— ·36	— ·04	·22	·74	1·34	1·16
9	·56	·95	·65	·36	·18	— ·21	— ·26	·13	·12	·74	1·34	1·14
10	·98	·91	·55	·33	·20	— ·21	— ·06	·03	·2	·72	1·23	1·16
11	·72	·66	·66	·35	·15	— ·05	·12	·11	·14	·65	1·24	1·16
12	·56	·68	·59	·31	·24	·10	·30	·24	·23	·56	1·13	·97
13	·29	·56	·74	·48	·41	·36	·45	·34	·33	·59	·94	·8
14	·11	·51	·69	·51	·39	·33	·49	·47	·35	·37	·7	·58
15	— ·05	·4	·60	·47	·58	·54	·51	·75	·40	·23	·36	·23
16	— ·36	·28	·53	·61	·68	·51	·50	·83	·40	·16	— ·01	— ·23
17	— ·81	·15	·47	·76	·75	·58	·56	1·03	·57	— ·14	— ·65	—1·02
18	—1·49	— ·18	·02	·66	1·18	·96	·82	1·73	1·87	— ·73	—1·99	—2·32
19	—2·36	—1·82	—1·58	— ·29	1·50	+1·65	1·64	2·27	1·94	—2·36	—3·28	—3·53
20	—2·94	—3·96	—3·83	—2·37	— ·22	·94	1·18	1·09	·01	—3·79	—4·69	—3·63
21	—2·86	—5·31	—4·80	—3·57	—1·75	— ·54	— ·47	— ·94	—1·72	—3·56	—4·28	—3·16
22	—1·93	—4·31	—3·62	—3·22	—2·47	—1·35	—1·47	—2·33	—2·75	—2·38	—2·21	—1·64
23	— ·59	—2·24	—1·41	—1·46	—1·83	—1·29	—1·75	—2·75	—2·41	— ·57	— ·75	— ·36

TABLE II.

Δ′D

Cape of Good Hope Hours (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon +34 min.												
0	·52	·63	·73	1·11	—0·6	—1·1	—·83	—2·17	—·62	·59	·48	—·02
1	·94	2·35	1·54	1·43	·33	—·02	—·58	—1·0	—·19	1·21	2·15	·96
2	·26	2·43	1·62	·03	·15	·38	—·25	1·17	·19	1·59	2·41	1·26
3	·58	1·76	1·27	·33	·13	·31	0·	1·17	·25	1·19	2·15	·84
4	1·07	·91	1·0	·33	—·44	—·06	·83	·33	·06	1·16	1·26	·64
5	1·03	·36	·5	—·49	—·61	—·34	—·58	—·67	·25	0	·81	·91
6	·58	·29	·68	—·26	—·48	—·31	—·5	·17	0	·19	·52	·8
7	·55	·69	·34	—·18	—·22	—·50	—1·08	·33	·14	·41	·96	·75
8	·71	·65	·78	·02	—·18	—·18	—·33	—1·32	·33	·56	·74	1·17
9	·81	·75	·73	—·03	—·02	0	—·42	·17	·14	·56	1·11	1·07
10	1·13	·75	·47	·16	·22	·05	—·08	·67	·23	·72	1·0	1·04
11	·68	·65	·66	·21	·18	·18	·08	·67	·22	·66	1·22	1·13
12	·45	·77	·63	·69	·37	·11	·33	·83	·37	·59	·89	·86
13	·19	·71	·71	·61	·44	·31	·75	·83	·34	·56	·78	·52
14	—·07	·91	·78	·72	·54	·45	·83	·83	·34	·44	·52	·37
15	—·89	·33	·43	1·05	1·18	·54	1·0	1·0	·49	·31	·33	—·01
16	—·35	·12	·35	1·0	1·09	·38	·5	1·33	·31	·31	·03	—·39
17	—·68	—·16	·36	1·28	·88	·54	·42	1·5	·61	—·12	—·59	—1·13
18	—1·06	—·73	—·59	·65	·96	1·02	·33	1·83	1·25	—·62	—1·52	—2·21
19	—1·51	—·77	—1·75	·08	·96	1·69	1·25	2·17	1·59	—1·28	—3·29	—2·96
20	—2·09	—3·89	—4·04	—1·93	—1·7	·82	·58	·5	—·27	—2·62	—3·37	2·5
21	—2·16	—4·61	—2·87	—2·46	—1·56	—·87	—1·0	—·17	—2·13	—3·19	—5·33	—2·05
22	—2·29	—2·34	—2·93	—1·25	—1·87	—1·76	—1·33	1·67	—2·37	—1·97	—2·81	—·93
23	—·65	—·68	—2·24	·11	—1·16	—1·59	—1·42	—2·83	—1·94	—·6	—1·59	—·37

TABLE III.

Δ″D.

Cape of Good Hope Hours (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon +34 min.												
0	1·36	—1·53	—·54	—1·07	—1·46	·91	—1·75	1·5	—2·81	2·75	·52	3·14
1	3·58	—1·21	·78	·21	—·72	—·81	·33	·17	·94	3·66	—1·92	2·96
2	6·71	2·0	2·5	3·66	+·74	—·45	2·75	—4·0	1·5	2·29	—1·7	1·7
3	3·55	2·44	2·35	1·67	1·0	—·5	1·81	—1·9	2·0	1·62	—1·59	1·45
4	—·32	2·68	·33	1·69	1·67	—·36	—4·67	·5	1·81	1·06	—·22	·43
5	—1·19	2·07	·5	2·1	·98	—·59	—·08	·83	—1·25	·41	—·11	—1·13
6	—·19	1·01	—·32	1·02	1·0	—·54	—·08	—1·83	·09	·62	1·04	—·79
7	1·13	·72	·08	1·24	·44	—·08	2·0	·5	·12	·81	1·07	·64
8	1·42	·75	—·31	·79	·65	—·47	—·17	1·0	—·75	·69	2·11	·25
9	·26	·68	—·24	·92	·56	—·83	·92	·17	—·09	·66	·93	·25
10	—·81	·08	·28	·31	—·07	—·83	·08	—3·0	—1·28	·09	·78	·46
11	·13	—·07	—·01	·33	—·15	—·54	·17	—2·83	—·56	—·06	·19	·16
12	·45	—·41	—·14	—·89	—·35	—·04	—·05	—2·67	—1·0	—·09	·85	·41
13	·45	—·52	·05	—·31	—·11	—·14	—1·33	—2·5	—·12	·06	·52	·96
14	·81	—1·37	—·27	—·31	—·41	—·14	—1·92	—2·17	·07	—·25	·63	·73
15	1·45	·24	·56	—1·11	—1·69	—·05	—2·67	—2·0	—·54	—·23	·17	·82
16	·13	·52	·61	—·9	—1·48	·41	·25	—2·17	·75	—·62	·06	·52
17	—·68	1·09	·37	—1·26	—·37	·12	·67	—1·83	—·12	—·03	—·33	·3
18	—1·94	1·95	2·02	·01	·57	—·17	2·75	—·5	4·0	—·28	—1·87	·39
19	—4·0	—1·17	·59	—·85	1·46	—·15	1·83	·33	2·37	—3·91	—1·96	—2·04
20	—3·64	—·35	·68	—1·01	—·15	·37	3·25	2·0	1·87	—4·22	—4·81	—4·12
21	—3·06	—1·63	—3·34	—2·61	—·61	1·06	2·67	—3·0	3·0	—1·25	2·96	—3·93
22	1·71	—7·33	—2·48	—4·49	—1·59	1·37	—·42	—2·33	—3·25	—1·31	2·26	—2·68
23	·19	—5·91	—2·76	—3·61	—1·81	1·01	—1·75	·5	—3·12	·19	3·11	—·41

§3. *Horizontal Intensity.*

In the case of the Horizontal Intensity the figures given by Sabine represent the value of the ratio $\frac{h}{\text{H}}$, where h is the value of the Horizontal Intensity taking the lowest hourly mean of that quantity for the month as zero, and H is the monthly mean value of the Horizontal Intensity. Knowing H we can readily obtain the daily inequality of the Horizontal Intensity to which Wolf's formula—

$$\Delta \text{H} = \Delta' \text{H} + r\Delta'' \text{H}.$$

is applicable in the same way as in the case of the Declination.

TABLE IV.

ΔH.

UNIT 1γ.

Cape of Good Hope Hour (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon +34 min.												
0	·4	— ·1	— ·4	— 1·3	2·1	— ·1	+ 8·8	7·1	5·6	— 5·0	— 4·0	·7
1	.8	— 1·7	·7	— 1·9	— 1·7	— 1·1	— 1·0	2·0	2·0	1·0	— 1·3	0
2	.5	— 1·5	1·0	— 1·5	— 2·6	— 1·2	— ·6	— 2·7	— ·8	2·8	·1	— 1·5
3	·9	— ·9	1·2	— 2·0	— ·9	·3	·9	— 3·7	— 2·5	2·2	·5	— 1·1
4	·3	— ·3	1·5	— 1·5	1·4	4·7	3·1	— 2·1	— 3·5	— ·4	— 1·2	— ·9
5	0	— ·5	— ·1	— 2·1	·9	3·8	2·4	— 1·2	— 4·5	— 2·7	— 3·5	— 2·2
6	2·0	— 2·7	— 3·5	— 4·9	— ·8	1·3	— ·4	— 3·3	— 7·3	— 4·7	— 4·6	— 3·3
7	— 4·3	— 4·9	— 5·8	— 5·7	— 2·5	— 1·8	— 2·7	— 6·2	— 7·5	— 5·7	— 8·4	— 7·1
8	— 5·6	— 5·5	— 6·5	— 6·1	— 4·9	— 3·7	— 4.1	— 6·8	— 8·3	— 5·6	— 6·2	— 7·7
9	— 6·2	— 5·0	— 5·2	— 5·9	— 6·1	— 4·9	— 6·4	— 7·2	— 8·4	— 5·3	— 5·0	— 6·1
10	— 5·5	— 3·8	— 5·0	— 4·3	— 5·2	— 4·8	— 6·8	— 6·0	— 6·3	— 4·3	— 4·2	— 5·2
11	— 4·2	— 2·8	— 2·8	— 2·3	— 5·1	— 4·3	— 5·7	— 5·1	— 3·5	— 2·9	— 2·8	— 3·9
12	— 2·3	+ ·2	— 1·9	— 5·0	— 3·1	— 4·2	— 4·8	— 3·9	— 2·6	— 1·6	— 1·0	— 3·4
13	— 2·1	·3	·7	1·4	— 2·3	— 3·7	— 3·2	— 2·8	— 1·0	— ·6	— 1·0	— 2·9
14	— 1·2	1·8	1·5	1·7	— 2·4	— 3·5	— 1·5	— 2·0	·5	— ·5	·2	— 1·7
15	·2	1·6	1·0	3·1	— 2·1	— 2·2	— 1·8	— 1·5	0	+ ·5	·1	— 2·2
16	·7	1·6	1·6	1·8	— 1·1	— 1·9	— ·6	— ·8	·1	+ ·4	1·4	— ·6
17	3·3	2·0	1·1	2·2	— ·8	— 2·0	— ·3	— 1·3	— ·1	1·6	3·7	2·9
18	6·1	4·5	3·5	3·6	1·6	— ·1	1·4	— ·3	·3	4·4	8·6	7·4
19	7·9	7·8	7·5	7·4	5·5	3·6	4·6	4·8	5·5	8·1	2·0	10·5
20	8·2	7·2	9·0	8·2	7·9	8·0	8·1	9·9	10·6	7·7	9·8	11·7
21	4·1	4·1	5·0	5·9	9·6	8·8	8·8	12·2	13·4	5·4	5·6	9·2
22	·8	— ·2	— ·1	3·7	7·6	6·7	7·5	11·6	12·2	1·4	·2	4·6
23	·7	— ·2	— 2·5	·5	4·7	2·7	4·9	9·5	7·6	— ·5	— 1·5	2·1

TABLE V.

Δ′H.

Unit 1γ.

Cape of Good Hope Hour (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon +34 min.												
0	1·0	—4·3	—3·9	—8·8	2·9	—2·7	—1·8	—3·5	5·4	—1·1	1·0	3·2
1	·6	—4·1	—1·7	—9·0	0	—4·1	—2·7	3·5	3·5	1·3	·9	5·6
2	1·5	—1·6	·2	—4·3	·9	—2·0	—1·7	—·3	1·6	2·2	·7	—2·0
3	2·9	—1·2	—1·0	—2·6	8·0	—·9	·6	1·9	1·5	2·2	.8	—1·0
4	2·5	—·3	0	—2·8	2·4	5·3	1·3	—1·5	—4·1	—·4	—5·2	1·0
5	—4·1	—·7	·7	—4·6	·7	3·0	—·1	3·8	—3·7	—6·2	—5·1	—1·4
6	—6·1	—2·8	—5·0	—6·2	—1·6	1·8	—4·0	—3·0	—7·4	—4·7	—6·7	—1·7
7	—4·2	—4·7	—5·1	—7·1	2·1	—·4	—5·3	—4·7	—8·3	—4·9	—8·2	—6·8
8	—5·0	—5·0	—2·8	—6·0	6·2	—2·7	—6·3	—1·0	—8·9	—3·4	—8·0	—8·3
9	—5·5	—8·8	—17·2	—5·7	—8·0	—3·3	—8·5	—4·0	—8·5	—6·9	—6·6	—7·8
10	5·7	—3·1	—6·7	—5·4	—7·7	—3·3	—9·8	—5·3	—8·9	—4·9	—5·2	—6·4
11	—2·7	—1·9	—3·9	—1·8	—5·0	—3·3	—5·7	—2·0	—3·2	—2·1	—1·5	—8·4
12	—2·1	·3	—2·1	·8	—3·8	—4·7	—3·0	—5·0	—4·3	—2·2	—1·0	—8·6
13	—·9	4·7	1·0	5·7	—2·9	—4·0	—·7	+3·0	—5·2	—·6	·4	—3·0
14	·1	1·3	2·5	7·0	—3·0	—3·3	2·2	.5	—·5	—·4	·8	—1·3
15	·4	2·7	2·4	6·4	—1·0	—·9	1·6	·6	·2	1·5	—8·0	—2·3
16	—1·0	2·5	2·5	4·9	—·3	—1·5	2·8	—1·3	·2	1·2	1·6	·8
17	3·5	3·1	·8	9·5	—·3	—2·2	4·8	—1·0	·4	2·5	2·5	·9
18	5·4	5·1	5·3	8·9	3·2	+·5	4·5	—1·2	·6	4·0	8·6	4·7
19	6.2	9·1	8·9	9·5	5·4	4·7	7·4	8·0	5·7	7·5	10·8	6·7
20	4·6	7·2	4·3	9·3	5·6	7·8	10·0	13·3	10·3	10·2	9·4	9·1
21	1·1	2·1	6·7	7·4	8·3	10·0	9·3	2·0	13·1	5·0	5·8	8·1
22	—·5	—1·2	—·4	2·8	6·7	6·3	7·5	2·3	9·4	·2	1·5	5·3
23	—1·0	—1·1	—3·1	—4·0	4·9	·2	2·5	—1·5	4·5	—3·0	2·6	5·0

TABLE VI.

Δ″H.

Unit 1γ.

Cape of Good Hope Hour (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon +34 min.												
0	—4·0	19·7	15·7	17·4	—2·9	15·0	14·2	41·7	1·4	2·5	—1·4	—9·0
1	2·0	10·9	11·7	16·7	—7·1	17·3	9·2	—6·7	—10·0	—1·1	—7·8	—5·0
2	—6·0	·9	3·2	6·9	—13·3	4·0	5·8	—9·0	—16·2	1·7	—2·0	1·4
3	—12·0	1·6	10·0	1·5	—11·2	7·5	1·7	—22·2	—25·8	0	—1·4	—·4
4	—7·4	·1	7·1	2·8	—3·8	—·4	10·0	—2·0	—15·7	0	·2	—4·9
5	24·0	1·3	—4·3	5·9	·9	·5	13·3	—19·0	—5·4	14·0	5·6	—2·6
6	—25·0	·7	7·3	3·1	2·9	—·3	15·0	—·8	+1·2	·4	7·9	—5·7
7	0	—·7	·7	3·2	—·9	—8·3	14·4	—5·7	6·0	—2·8	6·9	—·9
8	—3·0	—1·9	2·1	—·1	5·4	—6·0	12·5	16·0	4·1	—8·0	6·6	1·9
9	—3·0	—5.7	—3·5	—·5	·8	—8·7	12·7	—12·3	·6	6·5	5·9	5·8
10	1·0	—2·3	8·5	2·5	9·1	—8·7	16·7	—1·7	16·6	2·5	3·9	4·3
11	8·4	—4·4	4·5	—1·1	0	—6·7	1·2	—12·0	—2·1	—2·8	—3·7	—1·6
12	—1·0	—·9	1·0	—5·3	2·9	3·3	—10·0	4·0	11·5	2·4	0	·9
13	—6·9	—0·3	—1·7	—10·0	1·9	·2	—13·3	—12·5	28·0	—·2	—4·9	·3
14	—7·4	—23·1	—5·3	—12·4	2·5	—1·3	—20·0	—11·7	7·0	·2	—2·2	—1·5
15	—1·4	—5·3	—6·4	7·7	—3·8	—·8	—18·3	—8·3	—·7	—3·8	7·7	·1
16	—9·6	—8·5	—4·3	—7·3	—2·7	—·3	—18·3	2·5	—·7	—3·1	—·6	—4·8
17	—·8	—5·6	1·8	—7·9	—2·1	1·5	—27·0	—·8	—3·5	—8·4	4·2	7·1
18	3·0	—5·9	—8·2	—12·3	—6·3	—2·3	—16·0	4·0	—2·0	1·5	·2	9·5
19	14·5	—6·2	—6·1	—4·9	0	—4·7	—15·6	—14·0	—2·1	2·0	4·4	13·6
20	20·3	0	—23·2	—2·5	8·8	0	—10·0	—17·0	1·7	9·5	1·1	9·3
21	17·3	9·[illegible]	—6·6	—3·4	4·2	—5·7	—3·3	40·0	1·9	1·3	—·9	4·1
22	7·0	4·7	1·2	2·0	3·7	2·7	0	35·0	19·0	4·3	—4·7	—2·8
23	9·6	—4·0	6·5	10·7	—·9	15·3	6·7	45·0	22·5	9·5	14·9	—10·0

§4. *Easterly and Northerly Components.*

By the differentiation of the ordinary trigonometrical relation between Easterly Component, Horizontal Intensity, and Declination, and between Northerly Component, Horizontal Intensity, and Declination, we have—

$$\Delta Y = \Delta H \sin D + H \cos D \Delta D$$
$$\Delta X = \Delta H \cos D - H \sin D \Delta D.$$

A monthly mean value of D can be calculated from the records published by Beattie and Morrison in the TRANSACTIONS OF THE SOUTH AFRICAN PHILOSOPHICAL SOCIETY. We have then sufficient data for obtaining the daily inequality of the Easterly and the Northerly Components (Tables VII. and X.).

Again we have—

$$\Delta' Y = \Delta' H \sin D + H \cos D \Delta' D$$
$$\Delta' X = \Delta' H \cos D - H \sin D \Delta' D$$

with two equations of a similar nature for $\Delta'' Y$ and $\Delta'' X$.

TABLE VII.

ΔY.

UNIT 1γ.

Cape of Good Hope Hours (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon +34 min. 0	4·4	1·0	2·4	2·7	—2·1	—4·3	—5·7	—6·9	—2·9	4·5	1·2	4·9
1	8·9	9·7	9·3	7·0	—·4	—1·6	—3·2	—4·4	—·2	12·1	7·8	9·3
2	10·1	14·7	12·7	6·5	·8	·7	1·1	—·3	1·6	12·9	10·3	8·3
3	7·2	13·2	10·8	4·7	2·2	1·4	2·7	1·6	1·6	9·5	9·1	5·8
4	5·8	8·5	6·4	3·2	·1	1·4	—3·4	·9	0	1·0	5·6	3·6
5	4·1	4·7	3·4	1·2	—·9	—·9	—1·8	—2·4	—1·8	—·8	2·3	2·2
6	1·9	1·8	1·3	—1·5	—1·0	—1·8	—3·1	—3·1	—3·4	—·6	2·0	1·4
7	2·0	2·3	—·1	—·9	—1·5	—3·7	—4·7	—3·7	—2·9	—·5	2·3	1·3
8	3·0	1·8	·3	—1·1	—2·8	—3·5	—3·9	—3·3	—3·0	1·1	4·0	2·2
9	1·5	2·5	·9	—1·0	—2·1	—3·6	—4·5	—2·8	—3·5	1·2	4·5	2·9
10	2·5	2·8	·5	—·3	—1·0	—3·6	—3·6	—2·8	—1·7	1·5	4·3	3·5
11	1·6	2·0	2·0	·7	—1·7	—2·0	—2·2	—1·9	—1·0	2·0	5·2	4·1
12	1·8	3·6	2·2	—·8	—·3	—1·6	—·7	—·7	—·1	2·1	5·4	3·3
13	·5	2·8	4·1	3·2	1·0	·1	·8	·4	1·7	2·8	3·6	2·8
14	0	1·8	4·3	3·8	·9	0	1·8	1·4	2·0	1·8	3·5	2·3
15	—·3	2·9	3·6	3·9	2·0	1·6	1·8	3·2	2·1	1·4	1·9	0
16	—1·6	2·3	3·6	4·1	3·0	1·8	2·3	3·9	2·1	1·0	·6	—·9
17	—2·6	1·8	3·0	5·1	3·5	2·0	2·8	4·7	3·0	·1	—1·6	—3·9
18	—4·8	1·3	1·7	5·2	6·9	5·0	5·0	8·8	9·8	—1·6	—6·2	—8·3
19	—8·4	—5·7	—4·5	2·1	11·5	10·4	10·8	13·1	12·8	—8·3	—11·2	—13·2
20	—11·4	—17·1	—15·5	—8·3	2·8	5·3	10·1	6·7	5·1	—15·9	—19·6	—13·3
21	—12·9	—24·6	—22·5	—15·6	—4·4	1·5	1·9	1·1	—2·3	—15·9	—19·5	—11·9
22	—2·6	—22·5	—18·9	—15·0	—9·1	—3·7	—3·9	—6·2	—8·3	—11·7	—11·4	—6·2
23	—2·8	—11·7	—8·5	—5·8	—7·2	—5·4	—6·7	—9·6	—8·8	—3·2	—4·6	—·4

TABLE VIII.

Δ′Y.

UNIT 1γ.

Cape of Good Hope Hours (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon + 34 min.												
0	3·2	1·2	1·9	1·4	1·1	−7·0	−5·2	−13·0	−·6	2·6	1·0	1·5
1	5·2	10·2	7·2	2·9	1·7	−2·1	−4·3	−8·5	·7	6·9	11·6	7·8
2	2·1	11·8	8·5	−1·9	1·2	1·0	−2·1	6·0	1·8	9·4	12·8	5·6
3	4·4	8·6	9·0	·4	4·7	1·7	·3	7·0	2·0	7·3	11·6	3·9
4	6·8	4·4	5·2	·3	−1·1	2·3	4·9	1·0	−1·7	5·8	4·2	3·8
5	3·4	1·6	2·9	−3·8	−2·9	−·3	−3·0	−1·9	−·5	−3·1	1·7	4·0
6	0	·1	1·0	−4·5	3·3	−·7	−4·6	−·6	−3·6	−1·3	−·7	3·4
7	·8	1·3	−·7	−4·4	−·1	−2·8	−8·2	−4·0	−3·4	−·3	·9	·5
8	1·3	1·0	2·6	−3·1	2·2	−2·2	−4·8	−7·4	−2·7	1·2	−·2	2·0
9	1·5	2·0	4·3	−3·0	−4·1	−1·6	−8·4	·7	−3·5	−·5	2·5	1·8
10	8·7	2·4	−·9	−1·9	−2·7	−1·3	−5·3	·9	−3·2	1·3	2·6	2·3
11	2·3	2·5	1·5	·2	−1·6	−·7	−2·4	2·5	−·5	2·4	5·6	4·2
12	1·3	4·1	2·3	3·9	0	−1·7	·2	1·8	−·2	2·0	4·6	2·7
13	·6	6·0	4·2	6·0	·8	−·4	3·6	5·8	−·8	2·6	4·3	1·2
14	−·4	5·3	5·2	7·2	1·3	·7	5·4	4·7	1·4	2·1	3·1	1·3
15	−1·8	3·0	8·4	8·7	5·6	2·4	6·0	5·5	2·6	2·3	−2·3	−1·2
16	−1·9	1·8	3·0	7·6	5·6	1·3	4·0	5·3	1·7	2·2	·6	−1·6
17	−1·8	·7	2·3	9·5	4·5	1·7	4·6	7·3	3·4	·6	−1·9	−5·5
18	−3·0	−1·3	−·5	7·8	6·6	5·5	3·9	8·9	6·8	−1·2	−3·7	−9·2
19	−4·8	·5	−4·6	5·1	7·7	11·1	10·2	15·3	11·1	−3·0	−11·8	−12·1
20	−8·6	−16·6	−13·9	−5·4	1·9	8·2	7·9	9·0	8·6	−6·6	−12·8	−8·5
21	−10·7	−23·0	−11·6	−9·1	−4·0	·5	−·6	·1	17·6	−14·2	−24·8	−6·7
22	−12·1	−12·8	−15·4	−5·1	−6·4	−6·1	−3·2	−7·5	17·0	−10·1	−13·9	−2·2
23	−8·9	−4·0	−13·1	−1·4	−3·4	−8·2	−6·2	−15·4	12·3	−4·6	−7·0	1·0

TABLE IX.

Δ″Y.

UNIT 1γ.

Cape of Good Hope Hours (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon +34 min.												
0	5·1	1·3	4·5	3·0	−10·0	5·2	−1·9	28·1	13·9	15·5	2·0	·3
1	19·6	−·9	9·9	9·4	−7·1	4·4	6·3	−2·4	−·1	18·5	−13·9	13·0
2	31·9	10·8	14·5	21·4	−2·8	−·3	17·2	−21·2	−·3	12·8	−9·8	9·5
3	12·6	13·5	17·1	9·4	−·4	1·1	10·2	−21·0	−2·4	8·4	−9·0	7·3
4	−5·4	14·9	5·2	10·1	6·9	−·1	−19·3	1·6	1·6	5·5	−1·0	−·2
5	5·8	11·4	·5	13·7	5·5	−·7	6·2	−5·1	9·2	9·1	2·2	−7·1
6	−13·4	5·4	2·0	6·8	6·6	−4·2	7·1	−9·9	1·1	3·4	9·3	−6·9
7	5·9	3·4	·7	8·0	1·9	−4·5	17·6	−·2	3·6	2·8	9·0	2·9
8	6·0	3·0	−·6	4·1	6·1	−5·4	5·3	13·2	−1·9	−·4	14·3	2·2
9	0	·7	−2·9	4·6	6·9	−8·5	11·0	−5·2	−·2	6·6	7·7	4·2
10	−3·7	−·8	5·7	2·8	4·1	−8·5	8·7	−16·4	1·5	1·7	6·0	4·5
11	4·9	−2·6	2·1	1·2	−·8	−6·1	1·5	−20·7	−3·9	−1·7	−·8	0
12	1·8	−2·5	−·2	−7·2	−·4	1·4	−5·3	−11·9	·5	·7	4·5	2·5
13	−1·1	−12·7	−·6	−6·6	·3	·3	−13·5	−19·2	13·4	·2	·3	5·1
14	·7	−5·6	−4·0	−7·8	−·9	−2·9	−20·0	−17·1	·7	−1·2	2·2	3·1
15	6·8	−1·4	−·3	−9·6	−10·7	−4·3	−23·0	−14·5	−3·1	−3·1	4·7	4·3
16	5·2	·9	1·1	−8·3	−9·0	+·6	−7·8	−10·1	3·6	−4·7	0	·3
17	3·1	2·9	2·8	−10·4	−2·9	+1·3	−9·9	−9·9	−2·3	−1·9	·4	5·1
18	−8·6	7·2	8·4	−6·0	−·1	−2·0	6·3	−·6	19·8	−·8	−9·6	2·7
19	−14·6	−9·1	·1	−6·8	7·6	−3·1	1·7	−5·3	11·3	−19·3	−8·0	−3·8
20	−8·8	−1·8	−3·0	−6·5	3·6	1·9	11·9	+1·9	10·5	−26·7	−29·5	−16·8
21	−7·5	−4·0	20·7	−15·3	−1·1	2·8	12·3	4·4	17·5	−5·9	15·0	−18·4
22	12·3	−34·8	−12·3	−22·3	−6·5	8·4	−2·2	5·3	−7·5	−4·7	9·5	−15·3
23	5·7	−32·9	−11·1	−13·5	−9·8	12·9	−5·8	25·0	−5·0	5·7	23·6	−2·9

TABLE X.

ΔX.

Unit 1γ.

Cape of Good Hope Hours (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon +34 min.												
0	— 2·2	— ·7	— 1·2	— 3·0	4·5	2·3	4·1	12·0	8·0	— 4·3	— 5·3	— 1·9
1	— 3·8	— 7·5	— 4·5	— 6·2	— 1·7	— ·4	1·4	3·1	1·9	— 5·6	5·8	— 5·2
2	— 5·3	— 10·1	— 6·9	— 5·4	— 3·5	— 1·7	— 1·2	— 2·8	— 1·8	— 4·3	— 5·6	— 6·5
3	— 3·2	— 8·6	— 4·8	— 4·7	— 2·2	— ·4	— ·5	— 5·0	— 3·7	— 2·8	— 4·6	— 4·5
4	— 1·9	— 6·1	— 1·9	— 3·5	·8	4·5	5·5	— 2·8	— 4·0	— 2·0	— 3·5	— 3·0
5	— 2·3	— 3·2	— 2·0	— 3·0	1·5	4·8	3·8	0	— 4·1	— 2·6	— 5·2	— 3·7
6	— 3·3	— 4·0	— 4·7	— 4·8	— ·3	2·4	1·3	— 2·1	— 6·5	— 5·1	— 6·4	— 4·6
7	— 6·0	— 7·0	— 6·6	— 6·0	— ·5	— ·1	— ·4	— 5·0	— 7·0	— 6·8	— 10·9	— 8·9
8	— 8·0	— 7·3	— 7·7	— 6·4	— 4·1	— 2·3	— 2·6	— 5·8	— 7·8	— 7·1	— 9·3	— 10·0
9	— 7·9	— 7·1	— 6·4	— 6·2	— 5·8	— 3·6	— 4·9	— 8·6	— 7·6	— 6·8	— 8·2	— 8·6
10	— 7·7	— 6·0	— 5·9	— 4·7	— 5·0	— 3·6	— 5·7	— 5·3	— 6·1	5·8	— 7·3	— 7·9
11	— 6·6	— 4·1	— 4·3	— 3·0	— 4·8	— 3·8	— 4·8	— 4·7	— 3·4	— 4·4	— 5·8	— 6·8
12	— 3·6	— 1·8	— 3·4	— 5·2	— 3·4	— 4·0	— 5·1	— 4·1	— 2·8	— 3·0	— 4·2	— 5·8
13	— 2·7	— 1·3	— 1·5	— ·2	— 3·2	— 4·3	— 4·1	— 3·4	— 1·9	— 2·2	— 3·6	— 4·8
14	— 1·3	·1	— ·7	— ·2	— 3·2	— 4·0	— 2·7	— 3·1	— ·6	— 1·4	— 1·8	— 3·2
15	·4	·2	— 1·0	1·3	— 3·5	— 3·5	— 3·1	— 3·5	— 1·1	— ·3	— ·9	— 2·5
16	1·6	·6	— ·2	— ·2	— 3·0	— 3·2	— 2·9	— 3·1	— 1·1	— ·2	1·2	·2
17	5·3	1·3	— ·4	— ·3	— 2·9	— 3·4	— 1·9	— 4·0	— 1·8	1·8	5·1	5·4
18	9·7	4·5	2·4	·9	— 2·0	— 2·9	— 1·2	— 5·3	— 5·2	5·9	13·3	13·2
19	13·9	12·2	11·3	7·2	·4	— 1·7	— ·8	— 2·4	— ·9	13·8	19·9	19·4
20	15·9	18·1	19·2	14·2	7·5	— 2·0	3·6	5·4	9·6	18·7	21·2	20·4
21	12·1	19·5	18·6	16·8	13·4	9·3	9·1	13·3	16·7	15·0	17·4	17·2
22	6·4	12·7	10·7	12·7	13·8	9·7	11·8	16·9	17·6	8·1	6·7	8·8
23	2·3	6·5	4·2	4·7	9·5	6·0	9·4	16·4	13·6	1·3	·9	2·5

TABLE XI.

Δ′X.

Unit 1γ.

Cape of Good Hope Hours (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Noon +34 min.												
0	— 1·4	— 5·5	— 5·5	— 10·8	2·7	·9	·8	3·2	6·5	— 2·6	— 2·3	2·9
1	— 2·2	— 10·3	— 6·0	— 11·9	— 1·0	— 3·5	— ·6	5·9	3·5	— 2·4	— 5·4	2·1
2	·6	— 8·4	— 4·5	— 3·8	·4	— 2·8	— ·8	— 3·7	·9	— 2·7	— 3·5	— 5·3
3	·8	— 6·1	— 4·6	— 3·3	6·6	— 2·0	·5	— 1·7	·6	— 1·5	— 5·5	— 3·3
4	— ·9	— 3·0	— ·3	— 3·4	1·5	4·3	— 1·3	— 2·3	— 5·3	— 3·6	— 8·1	— 1·0
5	— 6·5	— 1·6	— ·9	— 2·6	2·4	3·6	1·0	4·9	— 3·9	— 5·4	— 6·7	— 3·8
6	— 6·9	— 3·1	— 6·3	— 4·7	·1	2·5	— 1·1	3·1	— 6·4	— 4·6	— 7·3	— 3·8
7	— 5·3	— 6·1	— 5·3	— 5·7	2·4	1·2	— 1·5	— 3·1	— 7·6	— 5·5	— 9·9	— 8·1
8	6·7	— 6·2	— 4·7	— 5·3	5·9	— 1·8	— 4·5	3·0	— 8·8	— 4·6	— 9·2	— 10·6
9	— 7·2	— 5·5	— 17·1	— 4·9	— 6·9	— 2·9	— 6·2	4·0	— 7·8	— 7·6	— 8·9	— 9·9
10	1·6	— 4·9	— 7·2	— 5·1	— 7·3	— 3·0	— 8·2	— 6·6	— 8·3	— 6·4	— 7·4	— 8·6
11	— 4·6	— 3·6	— 5·3	— 2·2	— 4·8	— 3·4	— 5·2	— 3·7	— 3·4	— 3·7	— 4·8	— 6·3
12	— 3·1	— 2·0	— 3·5	— 1·3	— 4·4	— 4·4	— 3·6	— 6·7	— 4·8	— 3·6	— 3·3	— 5·6
13	— 1·4	2·0	— ·2	3·0	— 3·8	— 4·4	— 2·8	·2	— 5·5	— 2·1	— 1·9	— 4·1
14	·3	— 1·6	·1	4·0	— 4·2	— 4·2	— ·5	— 1·7	— 1·7	— 1·6	— ·8	— 2·2
15	1·4	1·3	·8	2·5	— 4·3	— 2·4	— 1·5	— 2·4	— 1·2	·4	— 1·7	— 2·0
16	·9	1·9	1·2	1·4	— 3·5	— 2·4	1·0	— 5·0	— ·7	·1	1·5	11·8
17	5·0	3·2	— ·3	1·2	— 2·9	— 2·8	2·6	— 5·3	— 1·5	2·5	3·9	4·1
18	4·9	6·5	6·3	5·8	0	— 2·6	2·9	— 6·3	— 3·1	5·3	11·9	10·5
19	9·8	10·1	10·9	8·1	1·9	— ·8	2·8	·7	— ·5	10·1	19·0	14·3
20	10·1	17·6	24·2	13·7	5·3	4·4	7·0	10·2	9·7	16·5	19·0	15·2
21	7·2	15·2	14·1	13·5	11·7	11·3	11·0	2·2	17·6	13·6	20·5	12·9
22	6·2	5·8	8·3	5·8	11·2	10·6	10·4	6·8	15·0	5·9	9·8	7·3
23	1·1	1·0	3·9	— 3·8	7·6	5·8	6·3	6·9	9·5	— ·9	6·8	1·5

TABLE XII.

Δ″X.

UNIT 1γ.

Cape of Good Hope Hours (Astronomical).	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
+34 min.												
0	−4·2	22·2	15·3	18·4	1·7	11·4	18·0	32·9	9·3	−5·8	−2·7	16·9
1	−10·3	13·0	8·0	14·0	−4·1	17·4	7·0	−6·3	−11·4	−11·6	−1·2	−12·9
2	−20·0	−5·0	−4·5	−4·7	−13·8	4·8	−3·0	3·8	−18·5	−5·1	3·3	−3·8
3	−20·7	−5·6	1·9	−5·6	−12·7	7·9	−3·8	13·8	−28·2	−4·7	4·4	−4·5
4	−5·5	−7·7	5·2	−4·3	−10·2	−2·5	22·4	−4·1	−19·0	−3·0	·8	−5·5
5	5·5	−4·9	−5·1	−1·1	−2·0	6·0	11·8	−4·0	−1·1	0	5·2	1·0
6	−1·7	−2·3	7·4	−·2	−·4	−1·0	13·2	4·6	−1·3	−1·5	3·9	−2·3
7	−3·2	−2·7	·4	−·9	−2·1	−7·0	6·7	−6·4	4·9	−4·7	2·9	−2·6
8	−5·7	−3·9	2·8	−2·3	2·8	−4·8	11·4	−1·5	5·7	−9·0	−·4	1·0
9	−3·3	−7·0	−2·8	−3·0	5·5	−5·3	8·4	−11·2	·7	3·8	2·4	4·7
10	3·3	−4·5	6·8	1·3	8·1	−5·3	14·3	7·2	18·1	2·0	1·2	2·4
11	6·1	−3·6	3·9	−2·0	·4	−4·2	·5	−2·3	−·2	−2·3	2·7	−·9
12	−2·1	·4	1·4	−7·1	3·5	3·0	−8·6	10·2	12·9	1·8	−2·4	−·4
13	−6·2	−16·2	−1·6	−7·8	2·8	2·1	−7·8	−3·6	2·7	0	−5·8	−2·4
14	−8·7	6·7	−3·8	−9·9	3·4	·2	−11·8	−3·9	5·9	·9	−3·7	−3·4
15	−5·3	−5·3	−7·2	−3·5	3·6	−5·6	−8·7	−1·4	1·0	−2·9	6·2	−2·2
16	8·1	−4·5	−5·5	−3·8	2·0	−3·8	−16·7	8·6	−2·8	−·9	−·6	−5·7
17	1·2	−8·0	·5	−3·1	−·7	1·0	−25·5	4·6	−2·7	−2·9	4·7	5·3
18	8·2	−10·8	−12·0	−10·6	−7·2	−1·5	−21·9	4·9	−13·3	·5	5·6	9·4
19	23·2	−1·0	−12·0	−1·9	−4·2	−3·7	−18·9	−13·2	−8·7	13·1	9·5	17·7
20	28·2	1·0	−22·2	·7	8·1	−1·1	−18·1	−20·6	−3·9	4·0	15·0	20·0
21	23·7	3·9	15·5	4·7	5·5	−8·0	−10·6	43·5	−7·0	4·6	−9·4	15·0
22	1·3	25·4	8·2	14·9	7·8	−1·6	1·2	37·1	25·9	7·5	−10·6	5·4
23	7·9	13·3	13·8	19·9	4·5	11·4	10·8	37·7	27·6	7·8	3·9	−9·9

§ 5. *Discussion of Results.*

At the outset it is well to observe that the period over which the observations extend is unavoidably limited. In dealing with sun-spot effect it is advisable to consider at least one eleven-year period, so that it is difficult to say whether the various results I have obtained are truly representative of the average conditions for a whole sun-spot period; however, as far as comparison with other results of a similar nature is possible, they do not appear to be exceptional.

An examination of the tables shows that there is a marked resemblance between the variation of the daily inequality Δ and Δ′. This resemblance is noticeable in all the elements considered. On the other hand Δ″ shows very great irregularity. This may possibly be in part due to the shortness of the period under consideration. Chree, in Phil. Trans. of the Royal Society of London, points out that there are two maxima and minima in the daily inequality of the declination at Falmouth and Kew. Schmidt's results (Archiv. des Erdmagnetismus Heft I.) show that there are two maxima and minima in the values of ΔD for a period corresponding to that with which we are dealing at Toronto, Hobarton, and St. Helena. In this respect the Cape is no exception, as similar maxima and minima are readily observed in the case of the Declination results. The figures for the Horizontal Intensity, obtained from the same sources, also show agreement.

Consider the value of the ratio $\frac{b}{a}$ for each month, where b is the arithmetic mean of the quantities Δ'' for the month, and a is the arithmetic mean of Δ' for the same month. For purposes of comparison I have calculated from Schmidt (Archiv. des Erd. Heft I.) the value of the ratio for Declination and Horizontal Intensity for stations, Hobarton, Toronto, and St. Helena, and have collected corresponding results from Chree (Phil. Trans. [A], vol. 203). The latter, however, do not lend themselves so well to purposes of comparison with Cape results, as they refer to a period which does not correspond to that with which we are dealing. In the case of Declination at the Cape and St. Helena agreement is very conspicuous. For nearly the whole mean year $\frac{b}{a}$ increases or decreases together at the two stations.

	Cape.		Hobarton.		Toronto.		St. Helena.		Katharinenburg.		Pawlowsk.		Batavia.		Mauritius.	
	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.
I.	1·89	2·78	·43	·6	·69	·6	1·47	·9	·20	1·30	1·30	1·04	·60	·78	·63	·26
II..........	1·29	1·70	·58	·8	1·18	2·0	1·28	·9	·95	1·17	2·09	1·65	·45	·85	·25	·55
III.	·79	1·85	·52	·6	·59	1·2	·59	·7	1·10	1·12	1·20	1·62	·78	1·06	·23	·67
IV.	1·98	1·09	·85	1·4	·22	1·2	·60	1·1	·53	1·26	·51	·83	·55	·55	·55	·35
V..........	·84	1·16	·86	1·5	·38	1·6	1·19	·5	·53	·58	·68	·97	·71	·77	·86	·55
VI.	·9	1·82	·77	1·1	·23	·9	·61	·5	·60	·95	·48	·67	·46	·82	·35	·78
VII.......	2·24	2·77	·85	1·3	·51	1·8	2·09	3·0	·48	1·13	·54	·80	·74	·80	·80	·56
VIII. ...	1·63	5·17	·60	1·0	·37	·6	·29	·4	·34	·72	·40	·40	·57	·74	·69	·75
IX.	2·29	1·72	·48	·7	·24	·5	1·21	·4	·54	·85	·50	·58	·77	·73	·26	·69
X..........	1·26	1·09	·45	·5	·54	1·1	·65	·8	·71	1·47	·62	·97	·41	·84	·23	·70
XI.	·88	·95	·41	·8	·64	·9	·47	1·1	·88	2·39	1·07	2·10	·40	1·01	·52	1·29
XII.......	·79	1·0	·46	1·9	·73	1·7	1·31	·3	·42	·50	1·09	3·08	·52	·70	·18	·76

The seasonal values of the ratio show excellent agreement for the stations under consideration. We see from the figures that the maximum value occurs in winter. In the case of the Declination the only exception is Katharinenburg, where it is a maximum in the Equinox. Batavia and Mauritius are exceptions as far as the value of the ratio for Horizontal force is concerned. There may possibly be some explanation of these three cases other than that the maximum sun-spot influence occurs at different seasons at these stations.

	Cape.		Hobarton.		Toronto.		St. Helena.	
	D.	H.	D.	H.	D.	H.	D.	H.
Summer	1·14	1·4	·47	·9	·37	1·2	1·06	·8
Winter	1·53	2·5	·68	1·2	1·00	1·3	1·32	1·0
Equinox	1·42	1·4	·56	·7	·37	·9	·68	·7

	Katharinenburg		Pawlowsh.		Batavia.		Mauritius.	
	D.	H.	D.	H.	D.	H.	D.	H.
Summer	·49	·83	·52	·71	·49	·83	·39	·71
Winter	·61	1·30	1·39	1·83	·62	·78	·68	·66
Equinox	·68	1·15	·68	·94	·61	·78	·30	·60

In conclusion, I wish to record my thanks to Prof. Beattie for his many valuable suggestions and kind encouragement while this investigation was in progress.

THE EXPRESSION OF CERTAIN SYMMETRIC FUNCTIONS AS AN AGGREGATE OF FRACTIONS.

By Thomas Muir, LL.D.

(Read May 30, 1906.)

1. In the *Nouv. Annales de Math.*, xv., pp. 86-91, the following theorem is enunciated by E. Prouhet, namely, *Si* a, b, c, ..., f, g, ..., l *sont* n *quantités inégales et racines de l'équation* φ(x) = 0, *la somme des produits de ces racines prises* m *à* m *sera égale à*

$$(-1)^{\frac{1}{2}m(m-1)}\Sigma\frac{(abc\ldots fg)^{n-m+1}\,.\,(a-b)^2(a-c)^2\ldots(f-g)^2}{\phi'(a)\,.\,\phi'(b)\ldots\phi'(g)}.$$

Though not so stated, it is evidently intended that the elements $a, b, c, \ldots, f, g$ are m in number. Further, in the original there is a misprint of an l for a b in the numerator of the fraction, but it is otherwise clear that by $(a-b)^2(a-c)^2\ldots(f-g)^2$ is meant the product which Sylvester used to denote by $\zeta(a, b, c, \ldots, f, g)$.

It is also important to note that $\phi'(a)\,.\,\phi'(b)\ldots\phi'(g)$ is exactly divisible by $\zeta(a, b, c, \ldots, f, g)$, the quotient being the product of $m(n-m)$ binomial factors, namely, the binomials got by subtracting from each of the elements $a, b, c, \ldots, g$ each of the $n-m$ elements $h, \ldots, l$. Thus, when $n=4$ and $m=3$, the identity is

$$\begin{aligned}abc+abd+acd+bcd=&\ \frac{a^2b^2c^2}{(a-d)(b-d)(c-d)}+\frac{a^2b^2d^2}{(a-c)(b-c)(d-c)}\\&+\frac{a^2c^2d^2}{(a-b)(c-b)(d-b)}+\frac{b^2c^2d^2}{(b-a)(c-a)(d-a)}.\end{aligned}$$

The object of the present note is to point out that the property is not confined to the simple symmetric functions Σa, Σab, Σabc, ... and especially that, as a consequence of this, when the number of elements is even we obtain a generalisation of Jacobi's theorem regarding the difference-product.

2. The result depends on Laplace's expansion-theorem in determinants and on Cauchy's theorem that the quotient obtained on dividing $|a_1^p\ a_2^q \ldots a_n^t|$ by $|a_1^0\ a_2^1 \ldots a_n^{n-1}|$ is a symmetric function of $a_1, a_2, \ldots, a_n$. Thus

$$\begin{vmatrix} 1 & a & a^4 & a^5 & a^6 \\ 1 & b & b^4 & b^5 & b^6 \\ 1 & c & c^4 & c^5 & c^6 \\ 1 & d & d^4 & d^5 & d^6 \\ 1 & e & e^4 & e^5 & e^6 \end{vmatrix} = -\, a^4b^4c^4 . \zeta^{\frac{1}{2}}(a,b,c)\zeta^{\frac{1}{2}}(d,e) + a^4b^4d^4 . \zeta^{\frac{1}{2}}(a,b,d)\zeta^{\frac{1}{2}}(c,e) \\ -\, a^4b^4e^4 . \zeta^{\frac{1}{2}}(a,b,e)\zeta^{\frac{1}{2}}(c,d) + \ldots\ldots,$$

and dividing both sides by $\zeta^{\frac{1}{2}}(a,b,c,d,e)$ we have

$$\Sigma a^2bcde - \Sigma a^2b^2c^2 = \frac{a^4b^4c^4}{(a-d)(a-e).(b-d)(b-e).(c-d)(c-e)} \\ + \frac{a^4b^4d^4}{(a-c)(a-e).(b-c)(b-e).(d-c)(d-e)} \\ + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

The general form of the initiating alternant is

$$|\ a_1^0 a_2^1 a_3^2 \ldots a_m^{m-1} a_{m+1}^s a_{m+2}^{s+1} \ldots a_n^{s+n-m-1}\ |.$$

When s is less than m we obtain such results as

$$1 = \Sigma \frac{a^2b^2c^2}{(a-d)(a-e).(b-d)(b-e).(c-d)(c-e)},$$

$$0 = \Sigma \frac{abc}{(a-d)(a-e).(b-d)(b-e).(c-d)(c-e)}.$$

3. Taking now an even-ordered alternant of the form

$$|\ a^0b^2c^rd^{r+1}e^sf^{s+1} \ldots\ |$$

and expressing it in terms of two-line minors, we have in the case of the sixth order

$$\begin{vmatrix} 1 & a & a^r & a^{r+1} & a^s & a^{s+1} \\ 1 & b & b^r & b^{r+1} & b^s & b^{s+1} \\ 1 & c & c^r & c^{r+1} & c^s & c^{s+1} \\ 1 & d & d^r & d^{r+1} & d^s & d^{s+1} \\ 1 & e & e^r & e^{r+1} & e^s & e^{s+1} \\ 1 & f & f^r & f^{r+1} & f^s & f^{s+1} \end{vmatrix}$$

$$= a^sb^s . \zeta^{\frac{1}{2}}(a,b) . |\ c^0d^1e^rf^{r+1}| - a^sc^s . \zeta^{\frac{1}{2}}(a,c) . |\ b^0d^1e^rf^{r+1}\ | + \ldots\ldots$$

$$= a^sb^s . \zeta^{\frac{1}{2}}(a,b) . \{c^rd^r . \zeta^{\frac{1}{2}}(c,d) . \zeta^{\frac{1}{2}}(e,f) - c^re^r . \zeta^{\frac{1}{2}}(c,e) . \zeta^{\frac{1}{2}}(d,f) + \ldots\} \\ - a^sc^s . \zeta^{\frac{1}{2}}(a,c) . \{b^rd^r . \zeta^{\frac{1}{2}}(b,d) . \zeta^{\frac{1}{2}}(e,f) - b^re^r . \zeta^{\frac{1}{2}}(b,e) . \zeta^{\frac{1}{2}}(d,f) + \ldots\ldots\} \\ + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$
\begin{aligned}
&= \zeta^{\frac{1}{2}}(a,b)\,.\,\zeta^{\frac{1}{2}}(c,d)\,.\,\zeta^{\frac{1}{2}}(e,f)\,.\,\{a^s b^s c^r d^r + c^s d^s a^r b^r + \ldots\ldots\} \\
&- \zeta^{\frac{1}{2}}(a,b)\,.\,\zeta^{\frac{1}{2}}(c,e)\,.\,\zeta^{\frac{1}{2}}(d,f)\,.\,\{a^s b^s c^r e^r + \quad \ldots\ldots\ldots\ldots\} \\
&+ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots
\end{aligned}
$$

$$
= \Sigma\zeta^{\frac{1}{2}}(a,b)\,.\,\zeta^{\frac{1}{2}}(c,d)\,.\,\zeta^{\frac{1}{2}}(e,f)\,.\begin{vmatrix} 1 & a^r b^r & a^s b^s \\ 1 & c^r d^r & c^s d^s \\ 1 & e^r f^r & e^s f^s \end{vmatrix},
$$

where $\zeta^{\frac{1}{2}}(a,b)\,.\,\zeta^{\frac{1}{2}}(c,d)\,.\,(\zeta^{\frac{1}{2}}(e,f)$ is any one of the fifteen terms of the Pfaffian

$$
\begin{vmatrix}
b-a & c-a & d-a & e-a & f-a \\
 & c-b & d-b & e-b & f-b \\
 & & d-c & e-c & f-c \\
 & & & e-d & f-d \\
 & & & & f-e
\end{vmatrix}.
$$

When $r=2$ and $s=4$ this degenerates into Jacobi's theorem regarding the difference-product.

OBSERVATIONS ON THE FUNCTION OF THE ETHEREAL OILS OF XEROPHYTIC PLANTS.

By R. Marloth, Ph.D.

(Read March 30, 1906.)

It is well known that aromatic substances are widely distributed in the vegetable kingdom, for they occur in roots as well as in stems, leaves, and flowers. The scents of flowers evidently serve other purposes than those of the vegetative organs, for they act as an attraction to insects, which assist the plants in the process of pollination. Especially nocturnal insects are guided in this way to the nectar stored for them in the flowers, and it is for this reason that many flowers exhale their sweet perfumes only at night-time.

My remarks shall be confined, however, to another class of ethereal oils, viz., those occurring in the leaves of plants. They are found in almost every natural order, and in some of them their occurrence is universal. Consequently the function of these essential oils has been often discussed, although few experiments only have been made to ascertain their use.

In the earlier part of the last century these oils were often looked upon as mere waste products or excretions, which had to be removed from the body of the plant not only as useless but even as injurious to its own well-being. In modern times two views are held with regard to their function. One regards these aromatic substances as means of protection of the plants against animals, which are thereby deterred from feeding upon them. There can be no doubt that in many cases protection is obtained in this way, not only against grazing animals but especially also against the attacks by larvæ of insects, such as butterflies or moths, and the snails and slugs.

One has to distinguish, however, between plants that possess special internal reservoirs for storing the essential oil within their tissues and such which secrete them by special organs on their surface. In the former case, for which the orange and lemon, the parsley and celery, the laurel and the eucalyptus are well-known examples, there is hardly any difference of opinion with regard to the protective value of these oils, although authors, when dealing with the second group of plants, have not always been careful enough to discriminate properly between them.

Of special importance in connection with this question are the experiments on snails and slugs by Stahl.* He proved, fairly conclusively, that many plants which were not injured by snails, although the latter had no other food, were devoured by them eagerly when the essential oils had been extracted by means of alcohol or by drying. In the latter case the leaves had to be soaked in water before being offered to the snails. Stahl extended his experiments also to plants of the second group with identical results, but here his conclusions have not been accepted so generally, owing to another very ingenious explanation of the function of these oils. Plants belonging to this group are particularly numerous in the order Labiatæ; the thyme, peppermint, sage, rosemary, and our own wild dagga (*Leonotis Leonurus*, R.Br.) being familiar examples of this order.

This other theory is based upon the famous experiments of John Tyndall with regard to the influence which the vapours of essential oils have on the diathermancy of the air in which they occur. Tyndall † found that when heat-rays have to pass through such a mixture, a much larger proportion of them is absorbed than when they are passing through air alone, and that consequently an object enveloped by such a mixture of air and ethereal oil vapours would be less heated than when surrounded by air only. He filled a tube with a dried aromatic herb, such as peppermint, passed a slow current of air through the tube and examined this mixture of air and vapour in another tube with regard to its permeability for heat-rays. He found that air with the vapour of lavender gave an absorption of heat 32 times as great as that of air alone, thyme 33, peppermint 34, and wormwood 41 times.

When he employed the essential oils instead of the herbs by placing bibulous paper saturated with the oil into his first tube, he obtained much larger figures, for lavender oil gave 60, thyme 74, and oil of aniseed even 372.

When these observations became known to biologists, they thought that they had found an excellent explanation of the very common and general occurrence of aromatic plants in dry climates. It is a well-known fact that many plants of desert regions are strongly scented, agreeably or not with regard to our own olfactory organs as the case may be. It was thought that these plants, by surrounding themselves with an atmosphere of aromatic vapour, were able to guard off a portion of the heat of the sun's rays and that in this way their transpiration would be kept down considerably.

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* Stahl, E., "Pflanzen und Schnecken," Jena, 1888.

† Tyndall, John, "Heat Considered as a Mode of Motion," London, 1863, p. 360.

It must not be thought that the expression of this view is of isolated occurrence. On the contrary, several of our foremost biologists and phyto-geographers have accepted it. Haberlandt, in his "Physiological Anatomy of Plants," looks upon Tyndall's experiments as quite conclusive; Volkens, Drude, Warming, and others share his views, and MacMillan,* in "Minnesota Plant-life," adopts the same, as the following passage will show: "Many desert plants we know by their pungent odour, *e.g.*, wormwoods and sage-bushes. It has been shown that the vapour of the ethereal oils existing in such plants, when commingled with the atmosphere, reduces its permeability to heat, and thus the constant exhalation of perfume from the body of a wormwood is to be regarded as a device for tempering the heat of the sun."

On the other hand I must not omit to state that, as far as I have been able to ascertain, Tyndall himself never interpreted his results in this way, and that consequently the designation of this hypothesis as "Tyndall's theory" places the responsibility on the wrong person.

Some authors, however, did not accept this explanation, although, of course, it would have been very difficult to disprove it. Recently, Detto,† a pupil of Stahl, has repeated the experiments with snails and slugs in various ways, and has arrived at the conclusion that the function of these oils of exogenous or superficial origin is the same as that of the internally stored oils, *i.e.*, that they are means of protection of the plants against injuries by animals. "I do not think that this property of essential oils (viz., their diathermancy) is of greater importance to the life of the plant as, *e.g.*, their colour, their density, or their action on the polarised light."

I may say that I have arrived at the same conclusion, principally on account of observations made during the last twenty years in various parts of South Africa.

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* MacMillan, "Minnesota Plant-life," Report of the Survey, 1899, p. 467.

† Detto, Carl, "Ueber die Bedeutung der ätherischen Oele bei Xerophyten," München, 1903.

If the production of a diathermanic atmosphere around the plants would be the principal function of the ethereal oils, one should expect that the intensity of secretion would be largest during the hottest part of the day and the driest season of the year. That is, however, not the case in South Africa, neither in the Karroo nor in the South-Western region. On the contrary, a considerable number of plants, although very aromatic, emit hardly any scent under these conditions, but are bathed in odour during damp or foggy weather, even when dripping wet.

This behaviour of plants of both groups, *i.e.*, such with internal as well as with external organs of secretion, is, I think, fatal to the "diathermanic" theory, for how could we assume that substances which are produced by specially constructed and highly diversified organs should be so universally destined to be wasted!

The following plants have been observed by me to exhale their scent when the atmosphere is moist, but do not do so during dry weather:—

Coleonema album B. et W., *Diosma vulgaris* Schlecht., and many species of *Agathosma*—in fact, most Rutaceæ. The scent of Coleonema in misty weather is so strong that one notices its neighbourhood even yards away from it. Haberlandt has shown that the oil cavities of some plants of this order possess a specially constructed lid, which is thrown off, thus allowing the oil to escape, when the leaf is strained in any way, *e.g.*, when touched by an animal. I have noticed that the turgor of the leaf due to a plentiful supply of moisture at a time when there is no transpiration produces to some extent the same effect.

Another common plant of our hills and mountains behaves in a similar way—that is *Bubon Galbanum* L., the wild celery, also called the blistering bush. The leaves contain a highly volatile essential oil, but there is usually no scent about the bush, and our mountaineers did not know for many years that this was the culprit which produced the blisters on their hands, for the effect shows itself only a day or two after one has touched the bush. The virulence varies considerably, for sometimes one may handle a bunch of the plant unpunished, and at others a slight touch will do the blistering. The explanation is simple when once known. In dry weather one has to crush the leaves in order to obtain any effect, and even then I have sometimes failed when experimenting with it, but in damp weather the oil vessels burst at the slightest touch or movement of the bush, hence its fairly strong smell at such a time.

Even the common rhenoster bush, *Elytropappus rhinocerotis*

Less., is highly aromatic in damp weather, and its scent will then accompany you for many miles when travelling in the country. Other plants are *Elytropappus glandulosus* Less., *Relhania genistæfolia* L'Her., the so-called pepperbush of the Ruggens; *Osteospermum ilicifolium* L., of the mountain region, and the gland-covered, sticky *O. spinosum* L., of the hills; *Artemisia afra* Jacq., the Cape wormwood; many species of Pelargonium; *Malvastrum capense* G. et H., and even a dweller of the woods, *Plectranthus fruticosus* Lamk.

All these observations, incomprehensible if the hypothesis on the diathermanic function of the oils be accepted, are, however, in perfect accordance with the view that the oils act as a deterrent to animal enemies, and in particular to those which are to be feared especially in damp weather, viz., snails and slugs. It may be objected that there are no snails or slugs in the veld or on the mountains, as only some of the introduced species have become common in the gardens of the Cape. That is an error. I have found snails as well as slugs on various mountains of the South-West and also in karroid spots, *e.g.*, near Clanwilliam. One must, of course, not expect to see them on a dry summer's day. But when the South-East cloud covers the mountain for days, or when a nice drizzling rain is falling, you are fairly sure to find some, provided that you feel inclined to look for them. In fact, one of the introduced species from the Mediterranean, *Limax Gagates*, a black slug which is about three inches long, is so common in the upper part of the Platteklip gorge, that on such an occasion one may gather a dozen in a few minutes on the rocks near the top of the mountain. I have also collected an indigenous species of slugs (*Oopeltes*) and several kinds of snails (*Dorcasia*, *Natalia*, and *Phasis*) on the Winterhoek near Tulbagh and on the Zwartebergen, and I learn from Mr. Lightfoot that there are a fair number of indigenous species of slugs and snails at the Cape, although few of them only are occasionally common.

In conclusion I may add, that in many cases the protection against grazing animals obtained by means of these oils will be of more importance to the plants than that against snails or caterpillars, but that the little foes would probably rapidly multiply and endanger the existence of many plants if they were not guarded off in such an effective way.

DESCRIPTIONS OF SOME NEW SPECIES OF HYMENOPTERA FROM PEARSTON, CAPE COLONY.*

By P. Cameron.

(Read June 27, 1906.)

ANTHOPHILA.

Gen. OSMIA, Panz.

Osmia capensis, sp. nov.

Black, smooth, and shining; the underside of the antennal flagellum bright rufous below; the pubescence on the body pale (perhaps fulvous on fresh specimens); on the apex of tibiæ and on the underside of the tarsi rufous; wings hyaline, the stigma fuscous, the nervures black. ♀.

Length 7 mm.

Front and vertex obscurely shagreened, shining, the ocelli in a curve (· · ·); the hinder separated from each other by a distinctly less distance than they are from the eyes. Clypeus very smooth and shining, the apex slightly curled up, brownish. Labrum fringed with fulvous pubescence. Mandibles piceous for the greater part; the apical tooth long, becoming gradually narrowed towards the apex. Mesonotum obscurely, minutely punctured; the scutellum and post-scutellum closely, finely, but distinctly punctured; the latter, if anything, more strongly than the former; the scutellum is depressed slightly in the middle on the apical half. Pronotum very smooth and shining. Basal area of metanotum smooth, shining, not very clearly defined; the depression on the apical slope is wide, deep; it is obliquely narrowed above; below it is much widened; the top of the widened part is roundly curved and extends close to the outer edge. Calcaria testaceous; tarsal claws bright rufous. The middle of the front at the antennæ projects into a keel, which becomes widened below.

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* The species described in this paper were captured by my old friend, Professor Robert Broom, of Victoria College, Stellenbosch.

This is certainly not *O. globicola* Stadel. (also from the Cape of Good Hope); the distinct furrow leading from the ocelli to the antennæ (absent in the species here described) should separate the two; if Stadelmann's figure is correct, the fore ocellus is separated by a greater distance from the posterior than it is in my species. *O. fervida* Sm. from Natal appears to be, so far as can be made out from the incomplete description, a different and larger species. Only its ♂ has been described. In *capensis* the apices of the abdominal segments, under the hair bands, are lead-coloured.

GEN. PROSOPIS, Fab.

PROSOPIS ROBERTIANA, sp. nov.

First recurrent nervure interstitial, the second received near the apex of the second cubital cellule. Black; the head below the antennæ, *i.e.*, the face, cheeks, and clypeus, the anterior tibiæ in front, the hind tibiæ to near the middle and the basal joint of the hind tarsi, bright yellow. Flagellum of antennæ from the pedicle brown, black above. Wings hyaline, the nervures black. The yellow mark on the face broad above, not extending to the base of the antennæ, shortly obliquely narrowed; the central mark on the face small, square. ♂.

Length 5 mm.

Head closely punctured, the punctures on the face and clypeus more widely separated than they are on the front and vertex. The lower half of the front is raised in the centre, the raised part extending between the antennæ, widened below, bordered by fine keels, and bearing two longitudinal striæ. Mesonotum closely and rather strongly punctured; the scutellum is as strongly, but not so closely punctured. Metanotal area stoutly, irregularly, closely reticulated; it is bordered behind by a keel. Metapleuræ more strongly and distinctly punctured than the mesopleuræ. Abdomen shining, sparsely finely punctured.

Is not unlike *P. curvicarinata* Cam.; which species may be known by the first recurrent nervure being received in the apex of the first cubital cellule; it is also larger; the labrum and mandibles are yellow, not black; the lateral yellow marks on the sides of the face are longer, project more above, and, instead of being gradually narrowed to a point above, have the upper part narrowed, it being only half the width above, of its base; the yellow, too, is paler, not so orange-tinted. In *P. curvicarinata* the yellow mark on the face is twice longer than wide, not square.

GEN. HALICTUS, Latr.

HALICTUS ATROVIRIDIS, sp. nov.

Dark green, the apices of the apical three abdominal segments broadly rufo-testaceous; the four anterior tibiæ and tarsi, the base and apex of the hind tibiæ and the hind tarsi, except the middle of the metatarsus, rufo-testaceous, the rest of the legs black and covered with white pubescence; wings hyaline, the costa and stigma testaceous, the nervures black. ♀.

Length 3–5 mm.

Flagellum of antennæ rufo-fulvous, blackish above, apical half of clypeus bronzy coloured. Mandibles testaceous, black at the apex; the front is brassy tinted; the punctuation on the front and vertex is fine and close. Metanotal area closely punctured at the apex, the base more strongly reticulated, its apex bordered by a broad, smooth and shining band. Abdomen closely, finely punctured; the apical segments (perhaps also the basal) with bands of white pubescence on their apices; the apical segment is entirely rufo-fulvous; the middle area of a darker rufous colour. The second cubital cellule is of equal width throughout; the third abscissa of the radius is about one-fourth longer than the second.

The green colour is not so conspicuous as it is in the common *H. jucundus* Sm., which is a much larger, much more densely haired species, and its apical segments of the abdomen are not rufo-fulvous. In the larger examples of *atroviridis* the metanotal area is more distinctly reticulated-striated than it is in the smaller; in fresh examples the rufous colour on the apices of the abdominal segments is hid by depressed white pubescence; the basal abdominal segment may be largely tinted with violaceous; the mandibles may be black.

MASARIDÆ.

GEN. CERAMIUS, Latr.

CERAMIUS RUFOMACULATUS, sp. nov.

Black, the clypeus, except for a narrow black border on the sides and apex, almost the basal half of the mandibles, a broad transverse mark over the antennæ, its upper sides irregularly indented, the lower with an incision in the middle, the incision widest below, a broad line filling the eye incision, extending above and below it, below extending to the malar space, where it is united to an oblique mark; the temples for the greater part, the mark obliquely dilated upwards from the eyes towards the vertex, below obliquely narrowed downwards, a broad band on the upper side of the pronotum, the band gradually dilated towards the apex, a broad irregular mark on the mesopleuræ below the tegulæ and almost united at the bottom to a longer, narrower one, a short line on the sides of the mesonotum near the tegulæ, a longer, broader one in the centre near the end of the parapsidal furrows, the scutellar basal keels broadly, the sides behind them, the scutellum from shortly behind the middle, the post-scutellum, the part on either side of it broadly, the metanotum, the yellow extending on to the pleuræ, except on the two furrows on the apex, and an irregular mark on the apex between them; a broad band—dilated outwardly at the apex laterally and reaching close to the base of the segment—a line on the apex of the second to fifth segments, narrow in the centre, broadly dilated backwards on the sides, and the greater part of the sixth segment, yellow. The yellow on the upper part of the eye incision and on the pronotum is largely suffused with rufous. The fourth segment is rufous except for the yellow lines and for a broad line in the centre of the basal half; the fifth and sixth are for the greater part rufous; the ventral surface is rufous, except that the basal three segments are broadly yellow at the apex. Antennæ rufous, the scape yellow below. Legs rufous, the greater part of the coxæ and about the apical two-thirds of the femora, yellow. Wings hyaline, the base suffused with yellow, the rest with fuscous-violaceous, the nervures black. ♀.

Length 15 mm.

Head large, as wide as the thorax, deeply, roundly incised behind; the front and vertex closely finely punctured, almost bare; the clypeus more strongly but not so closely punctured; its apical part from near the middle depressed, more shining and more strongly punctured than the base; its greatest width is somewhat greater than its greatest length; the apex is broad, transverse, the extreme apex keeled, and bordered behind by a distinct furrow. Labrum rufous. The yellow on the base of the mandibles runs into rufous at their middle, the upper margin and the teeth are black. Pro- and meso-thorax, with the scutellum closely and strongly punctured, almost bare above, the pleuræ and sternum thickly covered with white pubescence, which is longest on the latter. Parapsidal furrows distinct. Scutellum large, slightly higher than the mesonotum, clearly longer than broad, narrowed and rounded at the apex, the base slightly raised and with a large smooth space in the middle; the sides are keeled, the apex has an oblique slope. Post-scutellum smooth and slightly raised in the middle. First abdominal segment with the apex raised, the raised part with an oblique slope and clearly separated from the base of the second; down its centre is a narrow furrow, which is less distinct in the middle and more distinct at the apex than at the base. Radial cellule sharply pointed at the apex; the second cubital cellule in front is about one-fourth of the length behind and not much more than the length of the space bounded by the recurrent nervures; the second of the latter is received distinctly behind the middle.

The yellow is paler on the metanotum and on the base of the abdomen than elsewhere.

The curved furrow uniting the antennæ is deep and clearly defined; above it, bordering the top of the black mark, is a ∧-shaped furrow, narrow, but distinct. On the top of the metanotum is a broad, curved keel, its sides curving distinctly downwards; from its centre a straight keel, as long as the lateral curves, runs straight down, it becoming narrowed below; these keels are one-third of the length of the metanotum, which has its sides broadly rounded; its apex is raised, roundly curved, narrowed laterally.

The coloration of the abdomen is not unlike that of *C. macrocephalus*, and it has also a large head like that species. The claws have a small, sharp, almost upright tooth near the base. The fine punctuation of the abdomen is as in *C. andrei* Br., with which it appears to be related in some respects.

VESPIDÆ.

GEN. BELONOGASTER, Saus.

BELONOGASTER PICTUS, Kohl.

Cf. Ann. k.k. Hofmus. Wien, ix., 324.

A very pale example, the black being only on the sides and apex of mesonotum, on the meso- and metapleuræ, and on the sides of the third and fourth abdominal segments; the yellow marks on the second abdominal segment are larger than usual; and there is no black on the legs.

This is the species usually named *B. rufipennis* and *B. griseus*.

SPHEGIDÆ.

GEN. OXYBELUS, Latr.

OXYBELUS AETHIOPICUS, sp. nov.

Black, a mark, sharply narrowed on the inner side, on either side of the apex of the pronotum, a spot on the outer edge opposite the tegulæ, an oval, oblique mark on the base of the scutellum at the sides, the apical lateral angles, forming a triangular large mark, two large semi-circular marks on the apex of the first abdominal segment, two longer, narrower ones, obliquely dilated on the inner third, and transverse lines on the apices of the following three segments, the lines becoming gradually wider, lemon-yellow. Legs black, the apex of the fore femora narrowly, of the middle more broadly below, and the base of all the tibiæ, lemon-yellow; the enlarged apical joint of the tarsi rufous; the calcaria pale fulvous; the tibial spines darker coloured. Wings hyaline, the nervures black. Apical half of the antennal flagellum rufous. Middle of mandibles broadly rufous. Scutellar spines large, longer than the width at the base; their apex with a rounded incision, longer than the width at the apex; the post-scutellar spine nearly three times longer than wide, roundly bent above, of almost equal width throughout, the apical incision triangular, large, as long as the width at the apex; in its centre is a moderately stout longitudinal keel, bordered by a few oblique ones; its sides yellowish, tinged with rufous. Scutellum strongly, but not very closely punctured; mesonotum more closely, but not so strongly punctured. Metanotum shagreened, opaque, irregularly transversely striated, except the basal area and the keels bordering and leading from it; the area is depressed, triangular, the length longer than the width at the base, which is closed by a transverse keel; the lower part of the spine is bordered by two keels between which are a few transverse ones; the two longitudinal keels are bordered at the bottom by a transverse one, which extends laterally beyond them; above it is a stout tranverse one forming with the keel of the large area a smaller, somewhat triangular area. Pro- and mesopleuræ strongly, closely punctured; the metapleuræ closely obliquely striated. Abdomen strongly and closely punctured; the apex of the segments depressed, the depression clearly defined, closely striated, more or less reticulated and pale-yellow. Last segment black, closely striated above, the sides keeled; below it is smooth and shining down the centre. Apex of clypeus depressed, smooth, shining, transverse.

The long scutellar spine of almost equal width and with the sides yellow distinguishes this species. In *capensis* the spine is black to shortly beyond the middle, the apex yellowish testaceous; in *spiniferus* it is much broader compared with the width, and is narrowed at the base; there is a stout keel down the middle of the scutellum; the central area on the metanotum is large and reticulated, the apex of the clypeus is not transverse, and the legs are largely bright lemon-yellow.

In *æthiopicus* the keel leading from the metanotal area is broad above, becoming narrower below; it is flat, smooth and shining.

ICHNEUMONIDÆ.

Hemitelini.

GEN. XENOLYTUS, Först.

XENOLYTUS RUFIPES, sp. nov.

Black, the abdomen from the second segment and the legs rufous; the legs darker in tint than the abdomen, the hind coxæ black; the basal four or five joints of the antennæ dark red; wings hyaline, the nervures and stigma black. ♀.

Length 5; terebra fully 1 mm.

Antennæ 19-jointed, stout, as long as the abdomen, the third joint slightly longer than the fourth; the last not quite so long as the preceding two united. Head and thorax shining, covered with a minute pile. Face closely, minutely punctured, opaque; the clypeus smooth and shining. Mandibles dark red, the teeth black; the upper is distinctly longer than the lower. Palpi dark testaceous. Thorax shining, closely, minutely punctured, the mesonotum more closely and strongly than the rest; the base of metanotum distinctly depressed; the basal area large, almost square; the areola large, 6-angled, transverse at base and apex; the basal half obliquely narrowed, about one-third narrower than the apex; there are two large basal lateral areæ; the apical is broad at the base, narrowed to a point at the apex; its inner side roundly curved; it forms almost a triangle; posterior median area occupies the entire apical slope; it is 6-angled. The middle of the mesopleuræ is smooth and shining; below it is obscurely, finely longitudinally striated.

Abdomen shining; the post-petiole finely, longitudinally striated. Areolet 5-angled; the recurrent nervure is received in the middle; the disco-cubital nervure has a minute stump behind the middle; the transverse median is received beyond the transverse basal. In the hind wings the transverse median nervure is broken distinctly below the middle.

Phygadeuonini.

GEN. LEPTODEMAS, Först.

LEPTODEMAS CARINISCUTIS, sp. nov.

Black, shining, the underside of the antennal scape, the face, clypeus, mandibles except the apex, and palpi, yellow, tinged with orange; the second and following segments of the abdomen red, largely tinged with black in the middle; the legs of a brighter rufous colour, their coxæ black except at the apex; the apex of the hind tibiæ and the hind tarsi infuscated. Wings hyaline, the nervures black, the stigma fuscous. ♂.

Length 5 mm.

Antennæ stout, tapering towards the apex; the basal half of the flagellum fuscous below. Face closely and distinctly; the clypeus less closely, punctured; it is clearly separated from the face by a furrow. Front and vertex distinctly punctured; the former is more opaque and more closely punctured than the latter. Thorax shining, closely punctured, sparsely pilose; the parapsidal furrows are on the basal third; the mesosternal furrow is wide, crenulated; the upper, apical part of the mesopleuræ is almost smooth. Scutellum prominent; its sides keeled on the basal half. Basal slope of metanotum depressed, oblique, smooth, with only lateral keels; the areola large, roundly narrowed to a rounded point from shortly beyond the middle to the base; in its centre is a stout longitudinal keel; the sides are irregularly longitudinally striated; the apex is slightly rounded inwardly; there are five clearly defined apical areæ, all strongly striated, except the posterior median at the top; the spiracular area is clearly defined and closely striated; the metapleuræ are irregularly striated towards the apex; below is a stout curved keel, there being also a stout keel between the coxæ. Abdomen closely and rather strongly punctured, including the post-petiole, which has prominent spiracles; the sides behind these are keeled, the keels extending slightly on to the post-petiole beyond them. Areolet 5-angled, narrowed in front; the recurrent nervure is received in the middle; the transverse median is almost interstitial; the disco-cubital angled and bullated in the middle.

BRACONIDÆ.

Gen. CARDIOCHILES, Nees.

Cardiochiles nigromaculatus, Cam.

One example. The size and form of the black markings on this species vary. For example, the black mark on the base of the mesonotum may be of equal width or it may be gradually narrowed towards the apex, *i.e.*, triangular; there may be a black mark on the base of the abdomen. The antennæ may be 37-jointed. The post-scutellum is flat, stoutly keeled laterally. The South African species may be grouped thus:—

1 (2) Back of abdomen, pleuræ, sternum, and mesonotum black	*fulviventris*, Cam.
2 (1) Back of abdomen and mesothorax not entirely black	
3 (4) Thorax entirely black	*nigricollis*, Cam.
4 (8) Thorax only maculate with black	
5 (8) Mesonotum with three large black marks	
6 (7) Pleuræ largely and the base of the legs black ..	*nigromaculatus*, Cam.
7 (6) Pleuræ immaculate	*trimaculatus*, Cam., *testaceipes*, Cam., olim *testaceus*. Cam., non Kreich., non Szép.
8 (4) Thorax not maculate with black	*testaceus*, Kriechb. (Cameroons.)

I fancy that a series of specimens would show that the size and number of the black markings on the maculate species vary.

EVANIIDÆ.

Gen. EVANIA, Fab.

Evania broomi, sp. nov.

Black; the apex of the fore femora and the tibiæ and tarsi obscure testaceous; wings hyaline, the nervures pale testaceous, the basal ones black; the metasternal process not forked at the apex. Pro-

and meso-notum shining, impunctate, as is also the scutellum; the parapsidal furrows deep, extending from the base to the apex. ♀.

Length nearly 4 mm.

Head shagreened, opaque, the front more coarsely shagreened than the rest. Malar space more than half the length of the antennal scape, not furrowed. Lower part of clypeus bordered by deep furrows, its apex smooth, brown. Antennæ placed shortly below the middle of the eyes; the scape is shorter than the second joint of the flagellum; the latter is nearly as long as the following two united. Hinder ocelli separated from each other by a distinctly greater distance than they are from the eyes—by almost twice the length of the antennal pedicle. Pro- and meso-pleuræ opaque, coarsely shagreened; the raised upper part of the latter shining, almost smooth. Base of metanotum shining, almost entirely smooth, the apex with some distinct transverse striæ; the rest of the median segment closely, finely, mostly longitudinally reticulated; the longitudinal striæ stronger and more distinct than the transverse. Abdomen, including the petiole, smooth and shining; the petiole slender, about twice the length of the upper part of the metanotum. The recurrent nervure is received shortly beyond the transverse cubital; the transverse median distinctly beyond the transverse basal; there is no distinct angle in the apical part of the radius. Hind tibiæ and tarsi with a few pale golden spines; the long spur of the hind tibiæ is two-thirds of the length of the metatarsus, which is as long as the following two joints united; the last is as long as the penultimate, but not so long as the third. The antennæ are longer than the body; are slender and fuscous below towards the apex.

Comes close to *E. levigena*, Kieffer, which has also an unforked metasternal process.

BETHYLIDÆ.

GEN. TRISSOMALUS, Kief.

TRISSOMALUS TRANSVAALENSIS, Dub.

Dr. Broom sends a Bethylid, which is certainly a *Trissomalus*, Kieffer (Ann. de la Soc. Scient. de Bruxelles, xxix., 105), and which is probably identical also with the type of that genus, namely, *Goniozus transvaalensis*, Dubuysson.* As, however, it does not quite agree with the description, I give one of it here.

Black, the scape and the pedicle of the antennæ, the mandibles, the anterior tibiæ and tarsi and the four hinder legs, except their coxæ, bright red; wings hyaline to near the base of the stigma, dark fuscous, slightly tinged with violaceous beyond the stigma and nervures black. ♀.

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* Ann. Soc. Ent. Fr., lxvi., 1897, 354.

Length 6 mm.

The third joint of the antennæ is almost twice the length of the second, *i.e.*, the pedicle; its base is pale rufous. Head above the antennæ distinctly, uniformly, but not closely, punctured; a stout keel between and below the antennæ; the space bordering it opaque, impunctate; there is a smooth line below the ocelli; which are arranged thus ∵; the anterior separated from the posterior by a distinctly greater distance than these are from each other; they are separated from each other by about one-fourth the distance they are from the eyes. Mesonotum sparsely punctured, the apex almost impunctate; the furrows indicated only close to the apex. Scutellum very smooth and shining. Base of metanotum opaque, alutaceous, the centre almost obscurely finely obliquely striated; the apical slope smooth and shining, as are also the metapleuræ, except at the base where there are a few striæ.

Head slightly wider than the thorax, transverse behind, as wide there as the length of the eyes and temples united; the latter slightly shorter than the eyes. Prothorax short; mesonotum wider than long. Scutellum large, wider than long, narrowed behind; bounded by a wide shallow furrow at the base, the furrow widened into foveæ at the outer edges. The metanotum is not so long as the mesonotum and the scutellum united. The first abdominal segment is furrowed down the middle on the basal half; the third abdominal segment is longer than any of the others. Sides of head and thorax covered sparsely with white pubescence. Antennal scape as long as the following two joints united; the third joint is shortly but distinctly longer than the fourth.

ON THE HYMENOPTEROUS PARASITES OF THE MEALIE STALK BORER (*SESAMIA FUSCA*, HAMPSON).

By P. Cameron.

(Read June 27, 1906.)

BRACONIDÆ.

Bracon sesamiæ, sp. nov.

Black, the oral region, malar space largely, the inner eye orbits narrowly, the outer on the top more broadly, mandibles, palpi, a large triangular mark on the upper half of the prothorax, tegulæ, an elongated mark bordering the apex of the middle lobe of the mesonotum, the greater part of the scutellum, the abdomen and the legs, except the hinder coxæ, rufo-luteous; the apex of the hinder tibiæ and the hind tarsi, black; wings hyaline, the stigma and nervures black. ♀.

Length 4 mm.; terebra 1 mm.

Cape Colony. Grahamstown (14th December).

Antennæ 29-jointed, stout, almost bare; the third joint longer than the fourth. Head and thorax smooth, thickly covered with short, white pubescence. Clypeus clearly separated; the middle separated from the sides by depressions. Parapsidal furrows distinct, the middle lobe distinctly separated. Abdomen short, not quite so long as the thorax; closely, minutely punctured; the suturiform articulation is distinct, roundly curved towards the base of the segment at the sides; there is a narrow, but distinct furrow on the apex of the second segment; the segments laterally at the apex are clearly separated. There is a deep, distinct, oblique furrow down the middle of the metapleuræ.

Probably the amount of rufous colour on the head and thorax varies; the metapleuræ may be rufous.

The cocoon is elongate-ovate, white, covered on the outside with longish hair. The insect escapes by a round hole near one end.

APANTELES SESAMIÆ, sp. nov.

Black, very smooth and shining except the metanotum and basal segment of the abdomen, which are opaque and coarsely shagreened. Basal half of flagellum fuscous; the legs rufo-testaceous. Wings hyaline, the stigma and nervures fuscous. ♀.

Length nearly 2 mm.

Cape Colony. Grahamstown (11th September).

Antennæ stouter than usual, not much longer than the head and thorax united; the third joint twice longer than thick, clearly longer than the fourth which is longer than thick; the others are as long as thick. Face rounded; separated from the clypeus by a distinct furrow. Temples broad, rounded. Mesonotum depressed, flat, its apex raised. Metanotum not areolated or keeled. First abdominal segment wider than long; its sides depressed; the depressions wide, clearly defined; the second is shorter, broader than long, aciculated, more shining than the first, but not so much as the following segments; the ovipositor distinctly projects, is stout, broad; the apical ventral segment is testaceous. The apices of all the segments are transverse. The legs appear to be stouter than usual; the spurs of the hind tibiæ are stout and are nearly as long as the second tarsal joint; the hind coxæ smooth and shining. The first cubital cellule is large, its apex broadly, roundly curved; there is a short stump of the cubitus beyond it.

The antennæ are thicker, the mesonotum more shining and depressed and the nervure bounding the first cubital cellule more rounded than they are in most European species. Against the light the cubitus can be traced to the apex of the wing; at the base it is straight, oblique. The prædiscoidal areolet is more than twice longer than it is wide at the apex, where it is straight, oblique.

ICHNEUMONIDÆ.

EXEPHANES NIGROMACULATUS, Cam.

Annals of the South African Museum, Vol. V., 1906, p. 161.

The example bred is a ♂, which has not been described. The basal third of the antennæ is red, the rest black except for a white band of five joints near the middle; the apical joints are serrate.

The sides of the face and the top of the clypeus above are yellow; the malar space is black. The tubercles and the scutellum broadly in the middle are yellow. The black band down the middle of the metanotum extends beyond the areola on to the lateral areæ. The abdominal petiole is more slender than in the ♀.

Komgha, 15th February.

The three species described above were sent me by Mr. C. P. Lounsbury, the Cape Government Entomologist.

ON TWO SPECIES OF ICHNEUMONIDÆ PARASITIC ON THE CODLING MOTH IN CAPE COLONY.

BY P. CAMERON.

(Read June 27, 1906.)

The two species of Ichneumonidæ recorded below were sent me by Mr. C. P. Lounsbury, the Cape Government Entomologist, as having been reared from the destructive Codling Moth (*Carpocapsa pomonella*, L.)

PIMPLINÆ.

PIMPLA, Fab.

PIMPLA HELIOPHILA, Cam.

The ♂ of this species was described in the Zeits. für Hymen. ü. Dipter. 1905, p. 343, from the Transvaal. Both sexes having been reared from the Codling Moth, I now give a description of the ♀.

Length 8 mm.; ovipositor nearly 2 mm. Rufous; the antennæ, head, the greater part of the fourth, the whole of the following abdominal segments, the sheath of the ovipositor and the greater part of the legs, black; the greater part of the anterior femora in front; their tibiæ entirely in front and a broad band near the middle behind; the extreme apex of the middle femora in front, a broad band shortly behind the middle of their tibiæ, and a much broader one on the basal half of the hinder tibiæ, extending from shortly behind the base to shortly beyond the middle, clear white; the four anterior tarsi rufo-testaceous; wings clear hyaline; the nervures and stigma black; the latter white at the base. ♀.

Palpi white. The base of the four posterior coxæ may be reddish, as may be also the middle joints of the hinder tarsi. Front punctured above, irregularly, more strongly transversely striated below; the vertex weakly punctured. Face closely, distinctly, somewhat strongly punctured. Thorax shining, closely, distinctly punctured; the median segment more closely and strongly than the rest; the base of the propleuræ is smooth, impunctate above. Abdomen closely punctured, more strongly than the thorax; the apices of the segments are shining. Areolet 4-angled; the transverse cubital nervures meeting in front; the recurrent nervure is received clearly beyond the middle. The amount of black on the apex of the abdomen and of red and white on the legs probably varies.

As I have stated, *l.c.*, the affinities of this species are with *P. melanospila*, Cam. (Annals S. Af. Mus., V. 1906, p. 115). The two may be separated thus:—

Breast black; the four anterior coxæ, trochanters, and the greater part of the rest of the legs yellowish; the hind femora red; the apex of abdomen not black	*melanospila*, Cam.
Breast rufous; the four anterior legs for the greater part and the hind femora black; the apex of abdomen broadly black	*heliophila*, Cam.

OPHIONINÆ.

HYMENOBOSMINA, D.T.

Hymenobosmina pomonellæ, sp. nov.

Black, the antennal scape and legs red; mandibles obscure testaceous; the teeth black; palpi pale yellow; the anterior coxæ pale yellow, the posterior black; wings hyaline, iridescent, the nervures and stigma black. ♀ and ♂.

Length 7 mm.; terebra 2–5 mm.

Face and clypeus closely, uniformly punctured, covered with silvery pubescence; the front and vertex are similarly punctured, but not quite so strongly. Temples obliquely narrowed. Thorax closely punctured, the mesonotum more strongly than the scutellum or pleuræ. The basal keels of the areola are more distinct than the apical; they are straight, oblique, and unite at the base; there is a large basal lateral area, the keels being broadly rounded; beyond this is a large, somewhat triangular area, not clearly bounded on the inner side; there is an indication of a small petiolar area. Tegulæ yellow.

As this species is not quite typical, I give a generic description of it.

Clypeus not at all separated from the face; its apex broadly rounded. Wings without an areolet; the transverse median nervure unbroken; parallel nervure received shortly above the middle; the transverse median nervure in hind wings unbroken. Metanotal spiracles small, oval, about twice longer than wide. Metanotum indistinctly areolated; the areola open at the apex. Abdominal petiole distinctly longer than the second segment; its post-petiole clearly nodose. Ovipositor half the length of the abdomen. Hind tibiæ spinose; the claws pectinated. Eyes parallel; slightly curved on the inner side above the middle. There is a small, but distinct, malar space. The single transverse cubital nervure is longish; the recurrent nervure is received at less its length beyond it. Antennæ shorter than the body.

NOTES ON SOUTH AFRICAN CYCADS.*—1.

(With Plates VI., VII., VIII.)

By H. H. W. Pearson, M.A., F.L.S.

(Read June 27, 1906.)

While the Cycads have been the object of much attention from the anatomical botanist and, particularly during recent years, from the morphologist, our knowledge of what may be termed the Natural History of the group remains very imperfect. It is most desirable that some attempt should be made to lessen our ignorance in this respect, not only on account of the interest which attaches to this family as the most primitive of living seed-bearing plants, but also in the hope that a study of the living plants in a state of nature and of the life-conditions to which they have become adapted will throw light upon problems presented by the imperfect remains of their extinct relatives. Our present state of comparative ignorance is due, however, to no lack of interest, but rather to want of the opportunities for investigation. Cycads for the most part inhabit districts in which means of communication are few, and it is only here and there that systematic field-observations are possible. It has thus arisen that for what we know of the family as living plants we are chiefly indebted to the horticulturist.

Although, as Lehmann quaintly observes, "Cycadeæ omnes, quae Africam australem inhabitant, neque in agris urbi Capensi propioribus, neque in omnibus totius coloniae partibus proveniunt, sed in iis tantum terrae tractibus, qui longo intervallo ab urbe absunt," nevertheless the localities of many species are fairly easily accessible and offer facilities for investigation. The following paper contains records of observations on four of these species. Some are of doubtful significance, and may prove to be unimportant. They are deemed worthy of publication as a contribution to a body of facts from which in time valuable inferences may be drawn. As will be evident, much of the information contained in this paper is furnished by correspondents who are able to pay frequent visits to one or other of the forms considered, and to whom I am deeply indebted.

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* Assisted by a grant from the British Association.

The species studied are *Encephalartos Friderici Guilielmi*, Lehm., *E. Altensteinii*, Lehm., *E. villosus*, Lem., and a species of *Stangeria*.

ENCEPHALARTOS FRIDERICI GUILIELMI, Lehm.*

(Plate VI., fig. 1.)

The species which is believed to bear this name is abundant on the dolerite ridges in the Queenstown and Cathcart districts. It does not extend further north than Hangklip (6,500 ft.), and can be followed in a southerly direction almost as far as the eastern continuation of the Amatola range. Drège collected specimens on the Windvogelberg, a long ridge which overhangs the town of Cathcart. These were apparently identified by Lehmann as *E. Friderici Guilielmi* (*fide De Candolle*), which was later reduced to *E. cycadifolius* (*Zamia cycadifolia*, Jacq.). While, however, Lehmann's figures and description of the cones of *E. Friderici Guilielmi* contain nothing which would exclude those of the species now under consideration, the description of *E. cycadifolius* as given by De Candolle is not applicable to them. It seems, therefore, that the name should be retained for this species, though the point must remain doubtful until reference can be made to literature not accessible in South Africa.

This species is a marked sun-plant growing under conditions of extreme insolation. Occasionally, as, for example, on the steep banks of the Thomas River near the railway bridge, it is found in the neighbourhood of water, but in all cases its habitat is such as to demand a high degree of adaptation to xerophytic conditions. The plant branches freely, chiefly from the subterranean part of the stem, and consequently the occurrence of "clumps" consisting of plants of various sizes is very characteristic. The trunk attains a height of 12 to 15 ft., and then gradually falls over to a recumbent or prostrate position, in which it still produces new leaves and cones apparently as readily as when it stood erect. Branching sometimes occurs above ground (Plate VI., fig. 1). The removal of a thin layer of soil from the base of the trunk exposes a dense mass of apogeotropic roots of the usual type. It was hardly to be expected that they would be so abundantly developed in such a loose, dry soil.

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* In the study of this species I have received much valuable assistance from my friend Mr. E. E. Galpin, F.L.S., of Queenstown.

Cones are produced freely, but, so far as can be ascertained, none of the plants on the ridges near Queenstown coned in 1905; the majority then bore old cones in a more or less disintegrated condition. Each crown bears a whorl of 4 to 6 cones (Plate VI., fig. 1), and both they and the crown are clothed with a particularly dense tawny wool (" tomento triticei coloris," *Lehmann*)—a condition which leads one to wonder how the pollen escapes from the male cone or gains entrance between the sporophylls of the female. The photograph reproduced was taken in September, 1905. Eight months later the cones had fallen away, and from the summit of the stem a new crown of leaves had arisen.

Owing to the comparatively high latitude of the locality of this species, its proximity to the lofty Stormberg-Drakensberg range, its distance from the sea, and its high altitude—4,700 ft. and perhaps even higher—it is probably exposed to stronger illumination and to a greater range of temperature than any other South African Cycad. Some idea of the climatic conditions may be gathered from the meteorological data for Queenstown (situated somewhat to the north of the centre of its area of distribution), which are given at the end of the paper. The range of temperature to which most members of this species are subjected must be considerably greater than that disclosed by the Queenstown records. While the dense tomentum which clothes the cones is perhaps an adaptation to this condition, it is not unlikely that the species is further adapted by modifications in certain stages of its life-history—as, for example, by a shortening of the periods of the development and germination of the pollen. Fertilisation must very generally occur, for in September 1905, seeds with well-developed embryos were abundant. A detailed study of its life-history therefore promises results of unusual interest, and will be undertaken when the next crop of cones appears.

ENCEPHALARTOS ALTENSTEINII, Lehm.

(*Bot. Mag. tt.* 7162, 7163.)

(Plates VI., fig. 2; VII., fig. 1.)

In the bush which clothes the steep banks of the rivers entering the sea in the neighbourhood of East London occurs the well-known arborescent *Encephalartos Altensteinii.* It is found in sunny situations in the more open bush (Plate VII., fig. 1), or clinging to the precipitous rock-faces overhanging the rivers, or, perhaps more frequently, in the dense shade of the forest (Plate VI., fig. 2). Very commonly associated with it, particularly in shaded localities, is the epiphytic fern *Polypodium africanum.*

Vegetative reproduction by subterranean branching is much less common than in *E. Friderici Guilielmi.* Branching above the ground-level is frequent, but, so far as I have seen, occurs only in specimens exposed to sunlight and growing not far from water. In the type usually met with the main trunk has maintained its vertical direction, while a lateral branch, at first almost horizontal, curves upwards and becomes parallel with its parent (Plate VII., fig. 1). A very remarkable case of branching may be seen on the steep left bank of the Nahoon River, some 20 ft. above water-level. Six lateral branches and a large bud arise from the main trunk about 3 to 4 ft. above the ground. Four or five feet higher up is the leafless top (May 1906) of the main trunk, and, just below it, five other stout branches and a multitude of undeveloped adventitious buds. The branches are all as thick or thicker than the main trunk. On one branch were the remains of a male cone. We have here a single plant bearing eleven crowns of leaves, and with every indication that its potentiality of branching is not yet exhausted. It will bear comparison with the old branched tree of *Cycas circinalis* represented in Kittlitz's picture (*Treas. Bot.*, pl. vi.), though in point of size it falls far behind the specimen seen in Natal by Sanderson and referred to by Sir Joseph Hooker in his account of this species (*Bot. Mag., l.c.*). The asclepiad *Tylophora syringæfolia* was epiphytic on two branched specimens of this Cycad; its tuberous stem-base was so tightly wedged in the angle between the branch and the main stem that it could not be removed entire.

No cones nor vestiges of cones were found on plants growing in the dense bush (May 1906). A minority of those exposed to sunlight shewed remains of male or of female cones, but no young nor perfect cones of either sex were seen. The production of cones by this species in this locality must be much less frequent than in *E. Friderici Guilielmi.* It may be noted that plants of *E. Altensteinii* under cultivation in Cape Town, far to the west of the eastern limit of the species and subject to very different climatic conditions, usually cone with great regularity at intervals of about two years. On the other hand, the cone figured in the Botanical Magazine (*l.c.*), from a plant grown near Norwich, appeared thirteen years after the one which immediately preceded it.

There is current a general statement that, except in the genus

Cycas, the cones are terminal on the stem, and that the latter in consequence becomes a sympodium. This is not true for *Encephalartos Friderici Guilielmi* nor for *E. Altensteinii*. In both cases we have in both sexes a group of three to six * cones arranged symmetrically round the apex (Plate V., fig. 1.). Later, when the apex resumes growth, the cones are displaced radially, and the next crown of leaves appears in the centre of the whorl of cones. It is clear, therefore, that in these species the summit of the vegetative cone remains vegetative and continues the growth of the stem.

ENCEPHALARTOS VILLOSUS, Lem.

(*Bot. Mag. t.* 6654.)

(Plate VII., fig. 2.)

This species is quite as abundant as *E. Altensteinii* in the East London bush. It appears that it is confined to shady situations (Plate VII., fig. 2), and never occurs on the open veld. The stem, said to be "rarely developed in imported and cultivated specimens" (*Thiselton-Dyer in Bot. Mag., l.c.*), seems to be always subterranean in its native bush; it is large and tuberous, and is covered by stout leaf-bases. The scale-leaves are densely villous. Apogeotropic roots arise from the top of the main root. Its leaves are longer and fewer in number than those of *E. Altensteinii*, but in other respects resemble them. Its range is extensive. It occurs in Natal, where, as I am informed by Mr. Medley Wood, "it is always found in shade, and the trunk never appears above the ground;" at Kentani in the Transkei (*Miss Pegler*); abundantly in the neighbourhood of East London; and I have received a cone from Messrs. Smith Bros., of Uitenhage, though I do not know that it occurs in the wild state so far west as this. Mr. James Sim writes that between East London and Kingwilliamstown it does not extend more than 20 miles inland.

In some localities at least this species rarely cones under natural conditions. Miss Pegler has sent me one male cone from Kentani, and has informed me of the existence there of another and of a plant surrounded by young seedlings; she states, however, that "cones are rare." From Mr. J. Sim I have also received a female cone obtained in the Grey Forest, East London. Messrs. Wood and Rattray, of East London, who have the plants in the immediate neighbourhood under constant observation, have never found cones, and I was unable to find any traces of them, though Mr. Rattray drew my attention to an old plant around which were growing a considerable number of small ones, apparently seedlings. On the other hand I found a male cone on a plant growing in a fairly open situation in the Queen's Park at East London, and saw a coning female in the garden of Mr. W. Smale, of East London. Mr. Smale, who has known this plant for fifteen years, informs me that, with one or perhaps two exceptions, it has produced cones annually. In cultivation in the northern hemisphere cones "have been repeatedly produced" (*Thiselton-Dyer, l.c.*).

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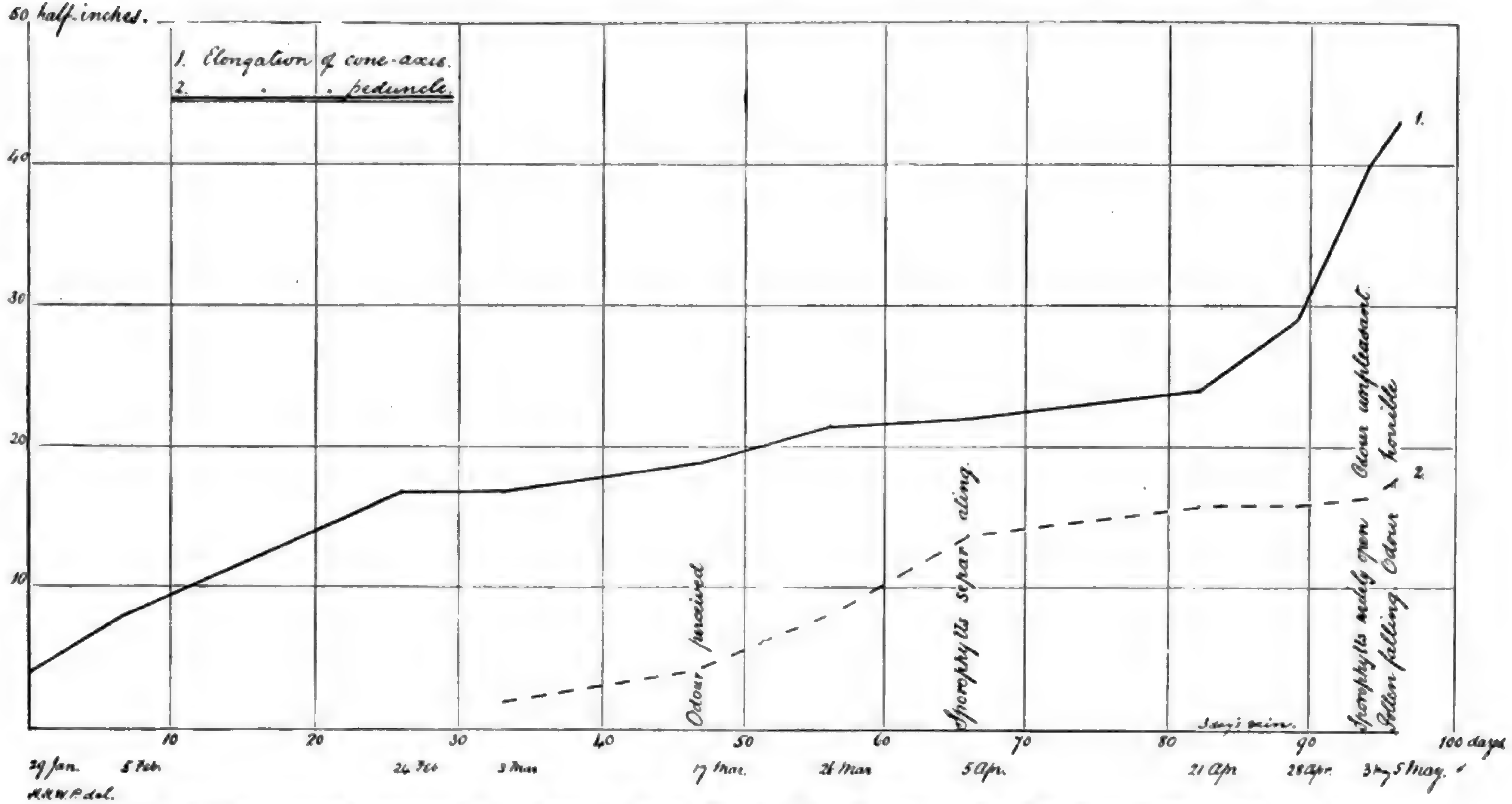
* But sometimes, apparently, in *E. Friderici Guilielmi*, the cone "ex apice caudicis solus egreditur et erectus" (*Lehmann*).

Miss Pegler has made the following observations on the rate of growth of a male cone on a wild plant growing on the bank of a stream-bed (usually dry) in the Kentani forests:—

Jan. 29.	Cone first seen; about 2 in. high.		Peduncle	0.
Feb. 5.	,, 4 in. high;	8 in. in circumference.	,,	0.
Feb. 24.	,, 8½ in. ,, ;	10½ in. ,, ,,	,,	0.
Mar. 3.	,, 8½ in. ,, ;	11 in. ,, ,,	,,	1 in. high.
Mar. 17.	,, 9½ in. ,, ;	11¾ in. ,, ,,	,,	2¼ in. ,,
Mar. 26.	,, 10¾ in. ,, ;	12 in. ,, ,,	,,	4 in. ,,
Apr. 5.	,, 11 in. ,, ;	12¾ in. ,, ,,	,,	7 in. ,,
Apr. 21.	,, 12 in. ,, ;	13 in. ,, ,,	,,	8 in. ,,
Apr. 28.	,, 14½ in. ,, ;	13¼ in. ,, ,,	,,	8 in. ,,
May 3.	,, 20 in. ,, ;	13½ in. ,, ,,	,,	8¼ in. ,,
May 5.	,, 21½ in. ,, ;	13½ in. ,, ,,	,,	9 in. ,,

On April 5th the sporophylls began to separate, and on May 5th they were open to their fullest extent and the pollen was falling freely. *See* Text-fig. 1.

The cone therefore shewed two distinct periods of growth, viz., from January 29th to February 24th, and from April 5th, when the sporophylls began to separate, until its elongation ceased on May 5th. During the intervening period of forty days the most rapid elongation of the peduncle occurred while the axis of the cone itself added only 2½ in. to its length. In Stangeria and in other species of Encephalartos it is ascertained that the microsporangia contain adult pollen-grains when the sporophylls begin to separate. It may therefore be assumed that during the forty days in which the elongation of the cone-axis was exceedingly slow, the development of the pollen-grains from an early condition of the archesporium was taking place. The greatly accelerated increase in length which occurred after April 21st may possibly have been influenced by a three days' rain, which fell between that date and April 28th, though the growth of the peduncle was not appreciably affected by it.



Text-fig. 1. ENCEPHALARTOS VILLOSUS, Lem. ♂ cone. Kentani Forest, 1906. Curve plotted from Miss Pegler's observations showing the rates of elongation of the cone-axis and peduncle. Ordinate divisions = five-inches; abscissæ = ten days.

Similar observations have not yet been made on a female cone in a state of nature. Mr. Smale saw the first sign of the cone referred to above on January 23, 1906; when I examined it on May 3rd it was 15 in. out of the ground (*i.e.* cone and peduncle) and the sporophylls were still closely shut.

Miss Pegler further observed with regard to the same male cone that on—

> March 17th the cone emitted a pleasant odour resembling that of fresh honey;
>
> May 3rd the odour had become unpleasant; several weevils were seen on the pollen-sacs but could not be captured;
>
> May 5th the odour was "horrible," penetrating and persistent. The weevils seen on May 3rd were no longer present, but in their place were many of a smaller kind.

Miss Pegler was able to capture several of the smaller weevils seen on May 5th. Mr. Péringuey has kindly identified these for me as *Phlœophagus hispidus*, Schh. This, and another species of the same genus, *P. ebeninus*, Schh., were among the numerous beetles which Ecklon and Zeyher collected "in Zamia Caffræ" (*Schoenherr*, 1,049, 1,051). All the specimens of *P. hispidus* obtained from this cone carried pollen on the hispid parts of the body, which would naturally follow from the condition of the sporophylls on the date of their capture. In addition there was a compact mass of pollen on the tip of the rostrum of every specimen examined (Plate VIII., fig. 1). The mass was securely attached, possibly by mucilage exuded from the tissues of the cone itself with which, indeed, other parts of the insect were besmeared. Mr. Péringuey informs me that the members of this genus usually feed upon the bark of trees, and all are winged. *P. hispidus* has at present only been found on Cycads. Too much stress must not be laid upon these few facts, but it may be admitted that they are sufficient to establish a probability that the weevil is concerned in pollination, and make it very desirable that further information regarding its habits and life-history should be obtained. With reference to this matter, it may be noted that the habitat of *E. villosus* and the position of its cones must, in most cases, render wind-pollination impossible, for the bush is usually so dense that the air a few feet above the ground can rarely move rapidly enough to enable it to carry even so light a substance as pollen. The same consideration applies, but in a somewhat less degree, to forest specimens of *E. Altensteinii*.

Strasburger discussed the pollination of the gymnosperms, and arrived at the conclusion, which has been generally accepted, that anemophily holds throughout the group. There are, however, indications that entomophily occurs in the Gnetaceæ (*Pearson*). On the ground that so many pollen-grains are found in the chamber of a pollinated ovule, Sir Joseph Hooker has recently suggested that the Cycads also are entomophilous (*Oliver* and *Scott*). This suggestion is supported by the facts now recorded as well as by the observation that a strong odour is developed in the male cones of a Cycas,* and probably also in other members of the family. That a very large proportion of the ovules of a cone become pollinated † must be regarded as additional evidence, for if the pollen were entirely wind-carried it might reasonably be expected that only those situated on the usually windward side of a bulky cone would receive pollen. So far as I am aware there are no records to show that this is ever the case. The whole question derives additional interest when considered in the light of the recently described structure of the cupule of the seed of the palæozoic Pteridosperm *Lagenostoma Lomaxi* (*Oliver* and *Scott*). It seems not unlikely that the entomophilous habit is of considerably older standing than has hitherto been believed. In this connection the fact that the group to which the genus Phlæophagus belongs includes what the entomologists regard as the most ancient surviving forms of the Coleoptera may not be without significance.

STANGERIA, sp.

(Plate VIII., figs. 2, 3.)

Among the grasses of the park-formation on the tops and upper slopes of the ridges near East London is found a species of *Stangeria*. Its distribution is very local, but where it does occur it is present in considerable numbers. It is present also, but sparingly, in the neighbouring bush. This form occurs also in the open country at Kentani (*Miss Pegler*), and as far west as Port Elizabeth (*Rattray*). It differs from *S. paradoxa* of the Botanical Magazine (t. 5121), which in Cape Colony seems to be confined to the forest, though forms which are more or less intermediate are occasionally found. The principal differences expressed in tabular form are:—

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* At present I know of no published record of this observation. I am indebted to Professor D. H. Campbell for the information.

† A large number of ovules removed at random from a cone of *E. Altensteinii*, from Amalinda, near East London, were dissected and the pollen-chambers fixed. Nearly all this material has been examined, and, so far, every ovule has proved to be pollinated.

Stangeria, sp.	*S. paradoxa* (*B.M.*, *t.* 5,121).
Petiole and rachis grooved on ventral face.	Petiole and rachis terete.
Great majority of leaf-segments with rounded or obtuse apices.	Apex of leaf-segment acuminate-acute.
Margin of leaf-segment in great majority, entire and revolute.	Margin usually flat and distinctly serrate.
Upper margin of sporophyll (♂ and ♀) usually rounded.	Upper margin of sporophyll usually more or less acuminate.

While the form characteristic of the open grass-veld is so distinct from that of the forest that one would not hesitate to regard them as different species, it must be admitted that the occasional appearance of a form to some extent intermediate between the two necessitates a fuller knowledge of both before a definite conclusion can be arrived at. The form occurring on the open grass-veld of East London and Kentani is usually known here as *S. Katzeri* (Regel), though neither the identification nor the claim of *S. Katzeri* to rank as a species is, in my opinion, sufficiently established. Mr. Medley Wood writes to me of plants which "I have frequently seen in Zululand . . . on the hillsides in quite open ground," and "the only difference which I can see between them and *S. paradoxa* is that the leaves, or some of them, are often slightly serrated, while those of plants growing in the shade are entire"—which is the reverse of our experience further south. The current statement that *Stangeria* is a monotypic genus can only be proved or disproved by the study of a large number of specimens from many different localities.

The forest-form of *S. paradoxa*, as is well known, was first described from Natal specimens. It is also recorded from East Pondoland (*T. R. Sim*, 2,490 !), and occurs as far south as the Manubi Forest (*Pegler*, 1,247 !), from which locality I have received an exceedingly interesting collection of male cones in various stages of development kindly obtained for me by Mr. S. Allen, of the Manubi Forest Station. These will form the subject of a separate paper.

The following remarks refer to plants growing on the open veld near East London. The stem is entirely subterranean and appears to branch profusely. Mr. Rattray has kindly been at the trouble to excavate a number of specimens, and finds that branching occurs quite commonly. The specimen figured (Plate VIII., fig. 3), which was sent to me by Mr. Rattray, shows three main branches, of which one (on the left) already shows clear indications of further branching. The whole stem is undoubtedly a sympodium. Remarkable as this specimen appears, Mr. Rattray referring to it says, "Even the specimen I sent gives you but little idea of the extent to which they branch. To-day I started to dig up what I hoped was a young plant, and found it to be only a small branch of quite a number." This habit will account for the fact that the plants are so frequently found in clumps. Each stem (or branch) produces one or two leaves and, so far as I have seen, never more than one cone (*cf. Bot. Mag., l.c.*), which arises from an involucre of scale-leaves. The cone stands a few inches above the ground, and is only seen on removing the surrounding grasses (Plate VIII., fig. 2.). The peduncle is sometimes six or more inches long, its length being probably dependent upon the height of the surrounding vegetation (Plate VIII., fig. 3). Specimens sent me by Mr. Wood from the vicinity of the Nahoon River show that the foliage also of plants growing among tall grasses becomes taller and more robust. The fact that the cones are concealed among the grass is opposed to the view that wind-pollination occurs. Further information with reference to this matter will, it is hoped, be forthcoming. Apogeotropic roots are usually found and are inhabited by a Nostoc. Their development is less marked than in *Encephalartos Friderici Guilielmi*, which grows in a drier soil.

SUMMARY.

1. Subterranean branching is a marked feature of *Encephalartos Friderici Guilielmi* and of *Stangeria*. In both cases it plays a part in vegetative reproduction not less important than in many ferns with subterranean rhizomes.

2. The cones are lateral in position in *E. Friderici Guilielmi* and in *E. Altensteinii*, and the growth of the stem is in both cases monopodial.

3. *E. Friderici Guilielmi*, which is subject to strong insolation, cones much more freely than either *E. Altensteinii* or *E. villosus*—both, especially the latter, being shade-species.

4. In *E. Altensteinii* cones are not infrequent on plants growing in more or less open positions exposed to sunshine. As far as is known they occur very rarely, if at all, on plants in densely shaded situations. A few observations support a similar conclusion for *E. villosus* (*cf. Pfeffer*, pp. 91, 92).

5. It is probable that other exceptional conditions such as are

implied in cultivation also act as a stimulus to the production of cones.

6. In *E. Altensteinii* branched specimens seem to occur only in illuminated situations (*cf. Pfeffer*, p. 93), and usually if not always, near water—conditions which are both favourable to nutrition.

7. There is a distinct probability that entomophily occurs in *E. villosus*. The position of the cones of *Stangeria* with respect to the surrounding vegetation points to the inefficiency of the wind as a pollinating agent.

Botanical Laboratory,
South African College.

METEOROLOGICAL DATA FOR QUEENSTOWN AND EAST LONDON.*

	Elevation.	Mean Annual Temperature.	Mean Warmest Month.	Mean Coldest Month.	Absolute Maximum.	Absolute Minimum.	Average Amount of Cloud.	Average Yearly Rainfall.	Approximate Proportion. Rainfall in 6 winter months. / Rainfall in 6 summer months.
Queenstown ...	3,500 ft.	61·4°	69·9°	51·2°	104·0°	19·0°	36·6%	26·9 in.	⅕
East London ...	20 ft.	64·8°	70·0°	60·0°	101·0°	37·0°	49·0%	23·37 in.	⅔

* Chiefly from Stewart, 1905.

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EXPLANATION OF PLATES.

Plate VI.

Fig. 1. A branched tree of *Encephalartos Friderici Guilielmi* growing on the top of a ridge (4,700 ft.) above Queenstown, with an unbranched specimen in the middle distance on the right. The branch on the left shews a whorl of 5 disintegrating ♂ cones, and the well-marked alternation of scale- and foliage-leaves. The doleritic boulders among which this species flourishes are also seen (September 23, 1905).

Fig. 2. *E. Altensteinii* in dense bush on the left bank of the Buffalo River near East London. Among the leaf-bases are numerous plants of the epiphytic *Polypodium africanum*. The walking-stick leans against the trunk of *Trichocladus ellipticus*. A young plant of *Buxus MacOwani* is seen at the base of the trunk of the Encephalartos. A little higher up, placed horizontally and slightly out of focus, are flowering branches of *Niebuhria triphylla* (April 30, 1906).

Plate VII.

Fig. 1. *Encephalartos Altensteinii*, in open bush on the right bank of the Nahoon River. In front of the branched trunk is a stem of the deciduous *Commiphora cariæfolia* (May 2, 1906).

Fig. 2. *E. villosus*, growing a few yards from the *E. Altensteinii*, shown in Plate VI, fig. 2. In the foreground in front of the walking-stick is an uprooted young plant showing the tuberous stem covered by leaf-bases (April 30, 1906).

Plate VIII.

Fig. 1. Rostrum of *Phlœophagus hispidus* with adherent pollen from ♂ cone of *Encephalartos villosus*, × 56.

Fig. 2. *Stangeria*, sp. Two leaves and a ♂ cone. Grass-veld near East London (May 2, 1906).

Fig. 3. *Stangeria*, sp. (♂), from the same locality, showing underground branching. In front of the specimen lie a ♂ cone (obtained by Mr. Rattray "among long grass") and a footrule. (Photographed by Mr. W. T. Saxton.)

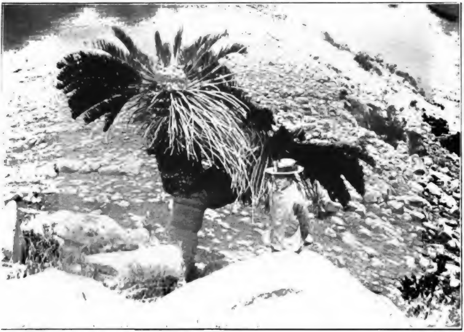
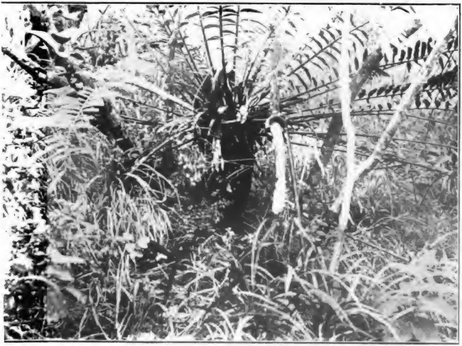


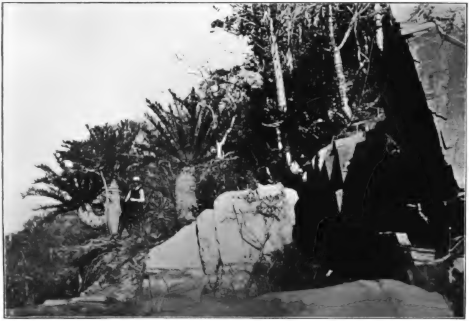
Fig. 1.



H. W. P. phot.

Fig. 2.

West, Newman proc.



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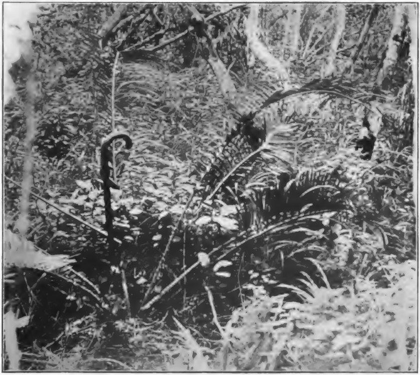

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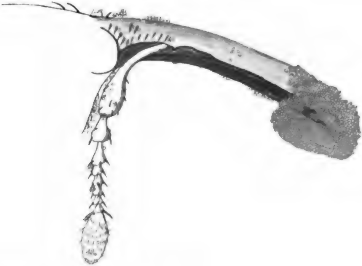

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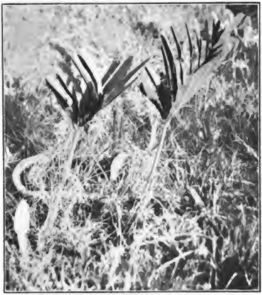
Fig. 1.



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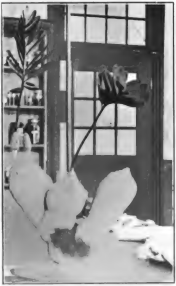


Fig. 3.

W. T. S. phot.

West, Newman proc.

ON THE EARLY DEVELOPMENT OF THE APPENDICULAR SKELETON OF THE OSTRICH, WITH REMARKS ON THE ORIGIN OF BIRDS.

By R. Broom, M.D., D.Sc., Victoria College, Stellenbosch.

(Read June 27, 1906.)

(Plate IX.)

Though the structure of the skeleton of the adult ostrich has been fully known for many years, almost nothing has been done, so far as I am aware, in the study of the early development. As the ostrich is one of the most primitive birds at present alive, it seemed to me advisable that the early condition of the skeleton should be examined, as it might possibly throw some light on the ancestry of the birds. Jeffery Parker has carefully studied the development of the skeleton of the *Apteryx*, and Kitchen Parker, besides his work on the development of the skull of the ostrich, domestic fowl, and other birds, has done much to elucidate the development of the avian appendicular skeleton. The early development of the bird's pelvis has been studied by Johnson and Mehnart, the early stages of the wing by Leighton in *Sterna*, and the early stages of the shoulder girdle and sternum of various birds by Miss Lindsay.

The study of the early condition of the ostrich skeleton confirms many of the facts discovered in other birds, and also enables us to add one or two points of interest.

I have examined two stages of the ostrich embryo, the one of 10 days' incubation and the other of 11 days. These are approximately equal to the 7- and 8-day embryos of the domestic fowl. The shoulder girdle and pelvis have been studied by tangential and transverse sections and the limbs by series of sections in the planes of the manus and pes.

Shoulder Girdle and Sternum.

The shoulder of the adult ostrich differs from that of all other birds in having a large cartilage bone lying in front of the coracoid, and it is also remarkable for the entire absence of the clavicle. Whether the anterior of the two ventral bones is a precoracoid or merely a process of the scapula has been answered in different ways by different authorities. Though many have regarded it as a precoracoid we may be pretty sure from what we now know of the morphology of the precoracoid in primitive reptiles that the bone in the ostrich is an anterior process of the scapula and is in no way homologous with the true precoracoid of early forms. A bony or cartilaginous precoracoid probably existed in all Stegocephalians, and it was inherited by the earliest reptiles. The Synapsidan group retained it in a well-developed condition owing to their having limbs for walking with the body well off the ground. Thus we find it in the Pareiasaurians, the Dinocephalians, the Therocephalians, the Anomodonts, and the Cynodonts. It is even handed on to the mammals and is present in *Ornithorhynchus* and *Echidna*. It is very doubtful, however, if any trace of it occurs in higher mammals. In the other group of reptiles, the Diapsidan, it was very early lost, and is only known to occur in the Pelycosauria, Mesosauria, and Procolophonia. In no other Diapsidan reptilian order does any trace of the precoracoid remain. Whatever may have been the ancestor of the bird, it is scarcely doubtful that it was a well-advanced Diapsidan reptile, and if the ancestor had already lost the precoracoid it is impossible for the descendant to have acquired it anew. Against the anterior ventral bone of the ostrich being the precoracoid there is also the pretty conclusive fact that it never has a distinct centre of ossification.

So far as I am aware the only work that has been published on the early condition of the ostrich's shoulder girdle is that by Miss Lindsay. She has dissected ostrich embryos said to be of 4, 7, 10, 15, 21, 25, and 27 days' hatching, and describes and figures a number of stages of the shoulder girdle. Unfortunately there is reason to believe that some serious mistake has been made in the age of the embryos. The embryo she figures as of 4 days is larger and more advanced than one in my possession of 8 days' incubation. It is possibly an embryo of 9 or 10 days' incubation. The one figured as of 7 days is distinctly larger and more advanced than one I have of 11 days. Probably it is an embryo of 12 days' incubation. Both figures are on too small a scale to show details accurately. In both, three toes are very distinctly shown on the hind foot, though in my specimens there is little external evidence of the second digit.

In the "4-day embryo" Miss Lindsay states that the "scapula and coracoid are not united," and also that "the coracoid and precoracoid are separate." A figure is given of this condition.

Unfortunately she does not state whether she regards the elements as chondrified. It is possible, however, that they are not, as she appears to be able to dissect out the elements of the shoulder girdle in the chick at a stage when sections "show comparatively little differentiation in the cells." Personally, I feel considerable hesitation in believing in structures which can be got by dissection but cannot be seen in microscopic sections. At any rate my results by microtome methods are very different from those obtained by Miss Lindsay.

In the 10-day ostrich embyro which I have examined, the whole shoulder girdle can be distinctly made out, but it is not yet fully chondrified. The coracoid and scapula proper are much better differentiated than is the descending process of the scapula. There is further no trace of a division between the coracoid and scapula: both are merely parts of a single bar. The coracoid is a short, broad structure, with a well-developed base for attachment to the sternum, but it does not yet meet the sternum. In the middle it is somewhat constricted and above it broadens out where it meets the scapula. The axis of the scapula makes with that of the coracoid an angle of about 100°. The upper part of the scapula is long and narrow and lies nearly parallel to the axis of the vertebral column. The lower end is broad and turned downwards to meet the coracoid. Anteriorly it is continued into a short, badly differentiated prescapular process, and on its outer side is a well-marked short process apparently corresponding to the "acromion process" figured by Jeffery Parker in the *Apteryx*. There is no clavicle present.

The sternum is very imperfectly differentiated, but can be fairly well traced. It is joined by 5 ribs, but none of the structures are as yet chondrified.

In the 11-day ostrich embryo the girdle is well chondrified except the prescapular process which is still procartilage. The coracoid is more elongated than in the earlier stage and now articulates with the sternum. The scapula makes with the coracoid a more obtuse angle than before and has its posterior end expanded somewhat. Anteriorly it curves downwards to the prescapular process, which is well developed but not chondrified. The process passes downwards and then slightly forwards and nearly reaches the base of the coracoid. As in the younger embryo there is no trace of a clavicle.

The most probable explanation of the phylogeny of the ostrich's shoulder girdle seems to be that it is descended from a reptilian type such as is seen in some Phytosaurs, where there is an elongated scapula and a short coracoid which is without a coracoid foramen.

When the ancestor of the ostrich became a flying bird the coracoid would become elongated to accommodate a large pectoral muscle, and there would, doubtless, be a large clavicle. The 10-day embryo still shows evidences of the flying ancestor in the well-marked angle which there is between the scapula and coracoid. As the power of flight became lost the clavicle disappeared. We find in the emu a shoulder girdle something like that which the primitive ostrich probably had before it completely lost the clavicle. As the clavicle disappeared its place was to some extent taken by the anterior process of the scapula, which gave a better protection to the front of the chest than the loose clavicle. There seems to me to be no evidence that the anterior process of the scapula is in any sense homologous with the precoracoid of the early reptiles. In a number of the higher Sauropsida the need for an anterior ventral bar to the shoulder girdle occurs, and in each the requirements are fulfilled by a process from the scapula. Thus in the Chelonians we get an enormous ventral scapular development, and in the Plesiosaurs the ventral development of the scapula is usually even greater than the dorsal.

ANTERIOR LIMB.

In the 10-day embryo the skeletal structures are first beginning to become distinctly chondrified, and only the larger elements can be made out with certainty. The radius and ulna are short, stout parallel bars, which are well differentiated. The carpus is represented by a large mass of procartilage in which is very clearly differentiated a large ulnare and less clearly a large distal element, which is probably the combined carpalia 1, 2, 3. The metacarpus of the pollex is very imperfectly defined, but the second and third metacarpals are well developed and quite distinct. There is a short but quite distinct fourth metacarpal. In fact the fourth metacarpal is very much more distinct than the first.

In the 11-day embryo most of the elements are well defined. The radius and ulna are large and of about equal size. In the carpus there are three well-defined elements—a very large radiale, a large distal element evidently the combined carpalia 1, 2, 3, and a small but very distinct ulnare. Four metacarpals are seen. The first, second, and third are all of large size, and developing phalanges can be seen on the distal ends of each. The fourth metatarsal is of small size, but still quite distinct.

In general appearance the manus is somewhat like that of *Apteryx* as figured by Jeffery Parker. In judging from one or two of his figures, one is inclined to think that probably the two forms resemble one another more closely than would appear from the figures. From his figures 258 and 259 there would appear to be a large radiale and a small ulnare as in the ostrich. But in those of the earlier stages he seems to interpret the appearances otherwise. He has failed to discover the fourth metacarpal.

There are one or two points in the structure of the early ostrich manus of considerable interest. The presence of four digits has previously been known in other forms. Leighton has figured various stages of the manus of *Sterna* showing the four digits, and there can be little doubt that the four in *Sterna* are the same as the four in *Struthio*. Whether these are to be regarded as I., II., III., IV., or II., III., IV., V., as Leighton seems to believe, might be discussed at some length, but the condition of affairs in *Archæopteryx* appears to conclusively settle the matter. There can be little doubt that the three-clawed digits of *Archæopteryx* are homologous with the three well-developed digits of the manus of the higher bird, and there can be as little doubt that these are I., II., III. from the phalangeal formula being 2, 3, 4. Kitchen Parker has also shown that in the manus of the chick the number of the phalanges proves the first two digits to be I. and II. It seems unnecessary to discuss the remarkable view of Hurst that *Archæopteryx* had five digits in the manus and that the digits that are preserved in the higher avian manus are III., IV., and V. The fact that the first and second digits have never more than 2 and 3 phalanges, and from their bearing claws are manifestly not degenerate, seems to me conclusive on the subject.

Another point of interest is the curious circumstance that the ulnare is differentiated earlier than the other carpal elements and also that the rudimentary fourth metacarpal is relatively larger at 10 days than at 11 days. From this we are perhaps justified in concluding that the fourth digit in the ancestor of the bird was well developed.

PELVIS.

The structure of the pelvis of the adult ostrich has long been known. In 1872 Garrod and Darwin discovered, in addition to the well-known elements, a small bone attached to the front of the pubis. This they believed to correspond to the "marsupial bone" of the lower mammals. Mivart, in his work on the ostrich skeleton, also refers to it, but expresses no opinion as to its homologies. In most text-books no reference is made to it, though Beddard mentions it and considers that it is conceivably a "marsupial bone."

The very early condition of the avian pelvis has been studied by Alice Johnson in the chick, by Mehnert in *Larus*, and by Jeffery

Parker in *Apteryx*. At first sight it might well seem superfluous to repeat such work even with a new type, but every one who has worked much at skeletogenesis will admit the very great difficulties of the subject—difficulties which lie not in the appearances so much as in the interpretations of the appearances. When cartilage is developed there is no difficulty in reconstructing and drawing the chondrified elements; the difficulty is with the procartilage—elements or parts of elements which are going to become cartilages or which ought to become cartilages but never succeed. In a good deal of the work which has been done in early embryos the difficulty is got over by ignoring the procartilage and only figuring the cartilage. But this method is comparatively useless. The procartilage is much more important to the morphologist than the cartilage, as it is the procartilage more than the cartilage that recapitulates the ancestral characters and throws light on the phylogeny. And in dealing with early embryos it is frequently well-nigh impossible to differentiate procartilage from other condensations of cells.

In the 10-day ostrich embryo the pelvis is well developed and much of it is chondrified. The ilium is of large size and is developed both much in front of the acetabulum and far behind it. The pre-acetabular portion is a deep, flat plate, which extends forwards in the direction of the lumbar vertebræ. Posteriorly the ilium narrows very considerably and curves downwards and backwards along the curved caudal vertebræ. The acetabulum is relatively of large size and is imperforate, being completely closed by the ilium, pubis, and ischium. The pectineal process is of large size, but it appears to be formed by the pubis rather than the ilium. If this be so, then the head of the pubis is unusually broad. The lower part passes downwards and curves slightly backwards, and is a slender, cartilaginous rod. At its lower end it passes into a broad sheet of procartilage which connects it with the ischium. Near the lower end of the cartilaginous portion a slight condensation of connective tissue or procartilage cells probably represents the early stage of the prepubis. The ischium has a very broad head which joins with the ilium and the pubis, and forms much of the acetabulum. From this it passes downwards as a broad bar of cartilage, then curves forwards as it passes into the sheet of procartilage, which unites it with the lower end of the pubis. There is no symphysis of the pubes or ischia, each being a considerable distance away from its neighbour of the opposite side.

In the 11-day embryo the condition of parts is much more like that of the adult. The pectineal process, though still large, is relatively much smaller. The pubis and ischium are longer and relatively more slender and they pass more backwards. The connecting band of procartilage is relatively much smaller, and the pubis passes down as a well-chondrified rod to a lower level than the ischium and curves inwards towards its neighbour. There is still, however, no symphysis, the two ends being considerably apart.

The condition of the pelvis is particularly interesting as showing that the avian type is not derived from one with the pubis and ischium apart, as in the carnivorous dinosaurs, but rather a modification of such a type as is seen in the pterosaurs. It further seems to show that originally the pubis and ischium were directed downwards and that the backward direction is a late modification.

HIND LIMB.

The hind limb of the adult ostrich is remarkable among birds for having only two developed toes—third and fourth—and even the fourth somewhat degenerate. There is, however, a rudiment of the second metacarpal. In other respects the arrangement of parts is as in normal birds.

In the 10-day embryo the condition is remarkably interesting. The tibia and fibula are fairly well chondrified and are of about equal length. The tarsus is mainly procartilage, but the elements are fairly distinct. The best defined is the elongated, partly chondrified fibulare, which lies near the distal end of the fibula. Near the distal end of the tibia is a large tibiale. When viewed from the front it forms more than two-thirds of the proximal tarsal row. When seen from behind, the tibiale is to a considerable extent hidden by a large rounded intermedium. There seems to my mind little doubt that this intermedium is quite a distinct element. In the distal row of the tarsus is a group of three more or less fused elements. These are evidently the second, third, and fourth tarsalia, and they are more or less distinct. To the radial side is a small procartilaginous element, which is probably the first metatarsal, but possibly the first tarsal. On the ulnar side lies a large procartilaginous rod, which is evidently the fifth metatarsal. The third and fourth metatarsals are of large size, and partly chondrified. The second metatarsal is much smaller and not distinctly chondrified. Developing phalanges are seen on the second, third, and fourth digits.

In the 11-day embryo all the elements are very much better developed, and the changes in some respects are remarkable. The lower end of the tibia is relatively very much larger, and in correspondence with it the anterior side of the tibiale is equally broad and overlaps the fibulare so as to almost completely hide it. The fibulare, though in the same relative position to the fibula and of the same shape as in the earlier stage, is relatively much smaller. The intermedium is still a distinct element, but is shifted a little more upwards towards the distal end of the tibia. The distal tarsal elements are not very distinct, but are probably second, third, and fourth tarsalia. The second, third, and fourth metatarsals are all well developed and chondrified. The first metatarsal is only partly chondrified at its distal end. The fifth metatarsal is quite small. Phalanges are well developed on the third and fourth toes, and a small phalanx is on the second toe.

There are a number of interesting points in connection with the development of the foot. In the first place it is interesting to note that the embryo ostrich has five toes more or less developed, and the three centre ones fairly well developed. We are probably justified in inferring that the immediate ancestor of the ostrich had three functional toes, and possibly that the more remote ancestor had a functional hallux. The 10-day embryo with its fifth metatarsal larger than the first suggests a more remote ancestor with all five digits functional, and possibly the outer four used for walking. The large size and early development of the fibulare suggests a well-developed outer side of the pes in a remote ancestor. And it is curious to note that in the manus there is similar evidence of an early greater development of the outer side. Another point of interest is the evidence that the ascending process of the astragalus is a true intermedium. This is confirmatory of the evidence obtained in various sea-birds by Morse, and in agreement with the opinion held by Kitchen Parker, Seeley, and others, though Jeffery Parker was unable to find any evidence of a distinct intermedium in *Apteryx*, and considers that the ascending process is a development of the tibiale.

THE ORIGIN OF BIRDS.

The origin of birds, like that of mammals, has for many years given rise to much discussion. But though a number of different views have been held, they have never differed from each other so widely as have the views concerning the origin of mammals. Gegenbaur, Huxley, and Cope, from their study of the anatomy of the dinosaurs, came to the conclusion that these extinct reptiles are intermediate in many points of structure between typical reptiles, such as the crocodile, and birds; and for some time it was pretty generally held that the ancestors of the birds were to be found among the dinosaurs. When, however, the dinosaurs became better known it was felt that all the discovered forms were too specialised to have been directly ancestral, and that it was more likely that dinosaurs and birds had sprung from some common form. Many went much further, and held that the resemblances between birds and dinosaurs were purely adaptive, and did not indicate any close affinity between the groups. Most of those who rejected the view that dinosaurs and birds are related favoured the theory that the avian ancestor was to be found among the pterosaurs. A few even adopted the very remarkable view that carinate birds sprang from pterosaurs and ratite birds from dinosaurs! Fürbringer in his great work on birds (1888) concludes that birds are monophyletic, and that the ancestral form was a sauropsidan lying intermediate between the Dinosauria, Crocodilia, and Lacertilia. Osborn has recently ably discussed the question, and comes to the conclusion that "the avian phylum may have been given off from the dinosaurian," and that "the dinosaur-avian stem hypothesis deserves to be very seriously reconsidered."

The extremely close resemblance between the hind limb of the bird and the carnivorous dinosaur is admitted by all, and the question to be decided is whether the bird could have evolved an almost identical mechanism from an undifferentiated primitive type such as is seen in *Palæohatteria.* The formation of a tibio-tarsus, by which a loose joint is converted into a firm joint, has pretty clearly arisen in connection with the support of the body on the hind limbs. In the case of the carnivorous dinosaur the stages of the formation are pretty clearly seen. Did the bipedal progression of the bird give rise to a dinosaur-like arrangement after the development of feathers or before? In the primitive bird *Archæopteryx* a tibio-tarsus and a tarso-metatarsus are already formed. But though *Archæopteryx* doubtless perched on its hind feet, it is not likely to have gone in for very much bipedal progression, and for both its climbing among the branches of trees and for perching the primitive type of tarsus would probably have amply served. The phalangers, lemurs, and many other mammals are probably quite as expert climbers as ever was *Archæopteryx*, and yet they have never evolved anything analogous to a tibio-tarsus or a fusion of the metatarsals, and with them the distal tarsal elements. The chameleon has a much better grasping foot than any bird, but the tarsus is not at all modified on bird-like lines. And it is clear that it is not the later typical bipedal progression of the bird that has evolved the tibio-tarsus, for it is as typically developed in *Archæopteryx.* If the habits of the primitive bird are not likely to have given rise to the typical avian mechanism, we seem to be forced to the conclusion that the mechanism was evolved at a still earlier stage and retained by *Archæopteryx*, even though probably not altogether perfect for its purpose; for though the bird foot is a good foot for perching it is not the best arrangement for climbing.

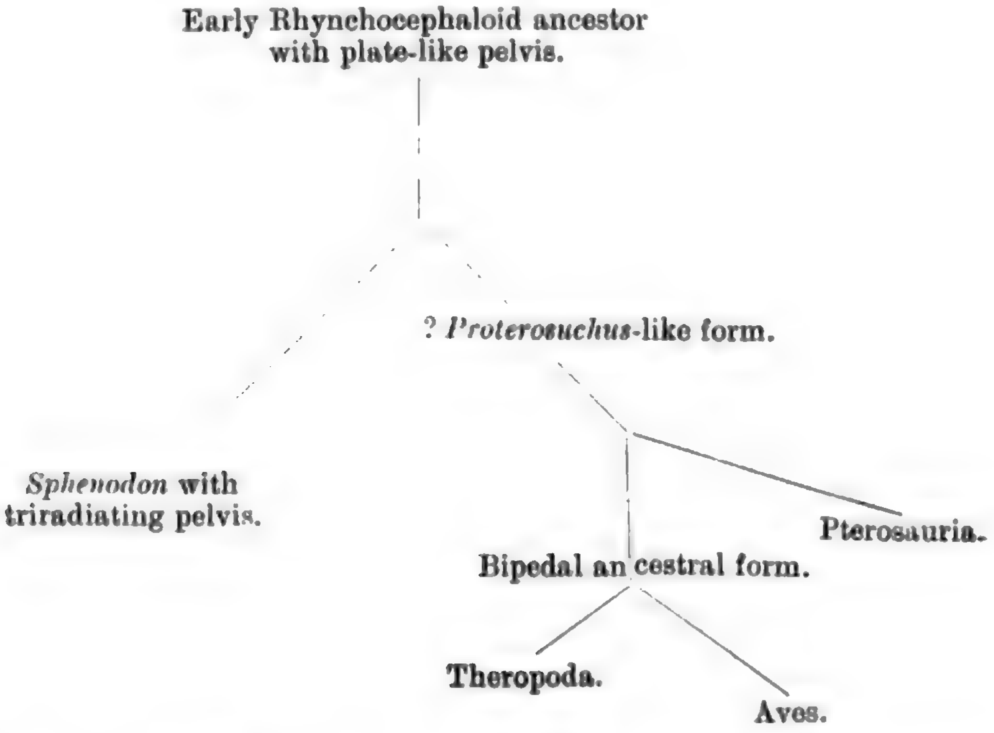
The immediate ancestor of *Archæopteryx* and other birds is likely to have been a small animal, since the power of flight is not likely to have originated except in a form small enough to take flying leaps, yet it seems impossible that a tibio-tarsus can have arisen except in an animal of very considerable weight. Small animals can hop about very satisfactorily with the ordinary mammalian type of tarsus. Even the fairly large kangaroo finds the mammalian arrangement with a little modification satisfactory enough without any anchylosis of the bones. It therefore seems probable that the avian mechanism arose in an animal which walked on the ground on its hind feet, and was sufficiently heavy to require a great degree of firmness in the tarsal joint. From the structure of the avian fore limb we may infer that this hypothetical bird ancestor had at least four digits in its manus. It probably also had a long tail, since the ostrich embryo shows evidence of at least twenty-six caudal vertebræ.

To what group would this bird ancestor belong? Clearly it must have closely resembled the carnivorous dinosaurs. Its hind limb was essentially similar; like some of them it no doubt had abdominal ribs; and most likely it had a fixed quadrate. In accentuating the differences of birds and dinosaurs a good deal has been made of the fact that the bird's quadrate is movable, but this is probably a secondary arrangement of very little moment. It seems very doubtful if *Archæopteryx* had a movable quadrate; and it is likely that there is some connection between the lengthening of the bird's beak and the movableness of the quadrate. As the beak lengthened the cranial arches became reduced, allowing of movement in the prefrontal region, and with it some movement of the quadrate. The pelvis of the ostrich embryo shows that though that of the ancestor was somewhat similar to that of the carnivorous dinosaur it was distinctly more primitive. It had the pubis and ischium joined ventrally enclosing an obturator foramen.

The resemblances between the avian ancestor and pterosaurs must have been much less than between it and carnivorous dinosaurs, and yet there is pretty clear evidence of some affinity. In the pterosaur there is no evidence of any bipedal stage either in the digits or tarsus, and it seems probable that it is descended from a quadripedal form of arboreal habits. The pelvis of the pterosaur has an expanded ilium, a united pubis and ischium with a small obturator foramen between, and in front a prepubis. The ostrich chick seems to point back to something very similar.

The most likely conclusion seems to be that somewhere in early Triassic times a Rhynchocephaloid reptile, with thecodont dentition and plate-like pelvis, gave rise to a small group of reptiles which walked rather than crawled. This ancestral group had an expanded ilium and well-developed limbs, and was probably in habits more like a mammal than a reptile. From an arboreal member of this group the pterosaurs have probably sprung. Others living more on the ground had the hind legs better developed, and in course of time came to be for the most part bipedal. From these bipedal forms probably both birds and dinosaurs were derived. For a time the birds balanced themselves like the dinosaurs by means of a heavy tail, and while they continued to have heavy tails the pubis and ischium would be directed mainly downwards. As the power of flight gradually developed the tail probably gradually became lighter and shorter, and to compensate for the loss of weight the pubis and ischium were directed more and more backwards, to support the muscles necessary to keep the body in an upright position. In the carnivorous dinosaurs the heavy tail was retained, and much less muscular effort would be required to keep the body up, and hence the ischium alone is developed in the posterior direction, and never to the extent seen in birds.

The relationships of the birds to the carnivorous dinosaurs and pterosaurs may be represented thus:—



The question might be discussed as to whether the common ancestor of the bird and the dinosaur should be regarded as a member of a distinct order or as a primitive dinosaur. Though in some few respects it no doubt differed from any known dinosaur, the differences would be too few to found a new order on, and I am of opinion that when discovered it will be regarded as the representative of a new sub-order only of the Dinosauria.

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For further references see Osborn's paper.

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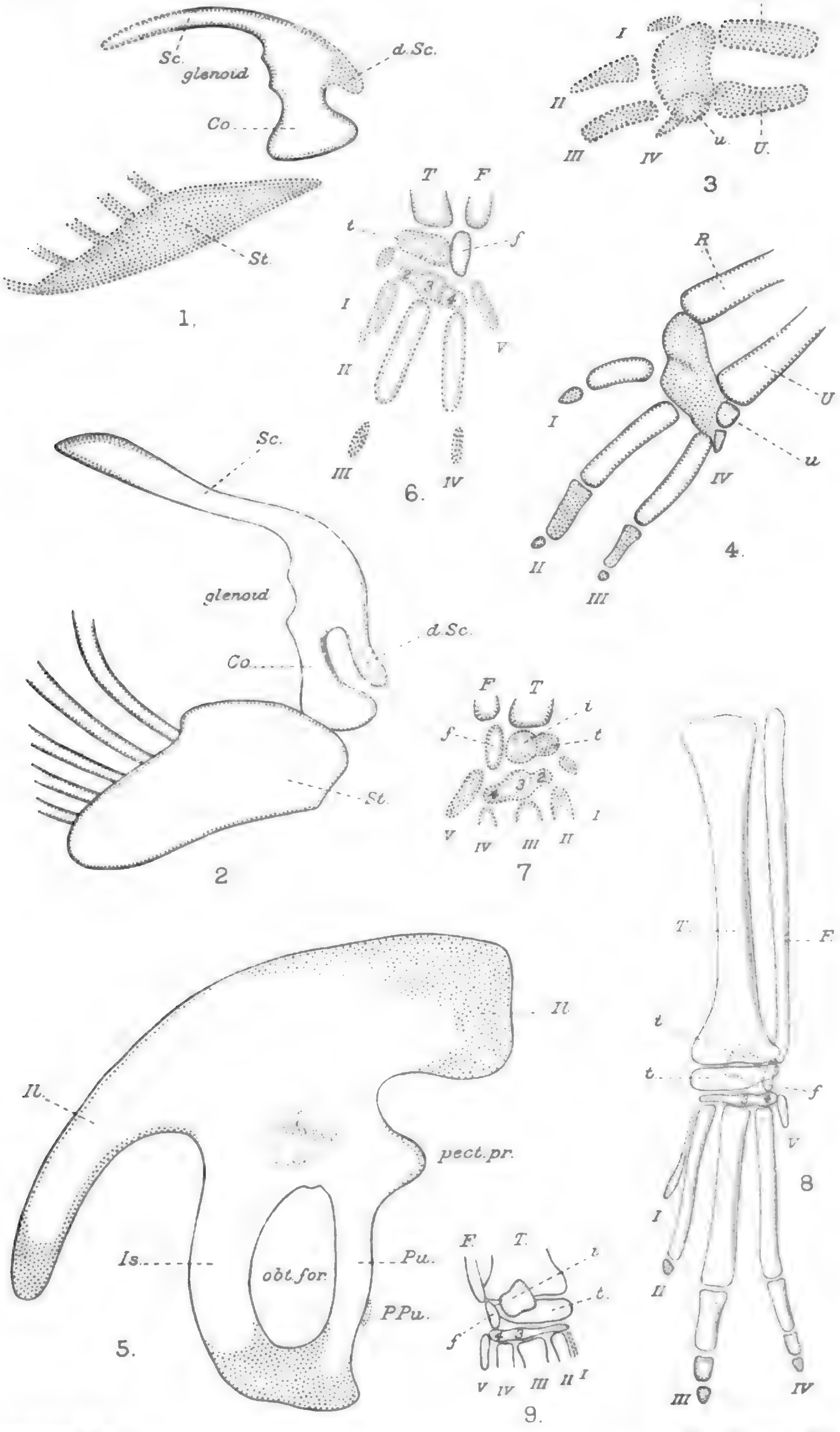
Co. coracoid; *d.Sc.* descending process of scapula; *F.* fibula; *f.* fibulare; *i.* intermedium; *Il.* ilium; *Is.* ischium; *obt. for.* obturator foramen; *pect. pr.* pectineal process; *P.Pu.* prepubis; *Pu.* pubis; *R.* radium; *Sc.* scapula; *St.* sternum; *T.* tibia; *t.* tibiale; *U.* ulna; *u.* ulnare; I., II., III., IV., V., 1st, 2nd, 3rd, 4th, and 5th metacarpals or metatarsals; 2, 3, 4, 2nd, 3rd, and 4th carpalia or tarsalia.

FIG.
1. Shoulder girdle of 10-day ostrich × 20.
2. Shoulder girdle of 11-day ostrich × 20.
3. Forearm and manus of 10-day ostrich × 20.
4. Forearm and manus of 11-day ostrich × 20.
5. Pelvis of 10-day ostrich × 28.
6. Pes of 10-day ostrich from before × 20.
7. Tarsus of 10-day ostrich from behind × 20.
8. Hind limb of 11-day ostrich from before × 20.
9. Tarsus of 11-day ostrich from behind × 12.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R. Broom del. West, Newman lith.

SKELETON OF OSTRICH EMBRYOS.

ON SOME LITTLE-KNOWN BONES OF THE MAMMALIAN SKULL.

By R. Broom, M.D.

(Read June 27, 1906.)

The structure of the mammalian skull is usually assumed to be pretty thoroughly known, and in most text-books descriptions or diagrams are given of the various bones. Flower's well-known diagram has been repeated with or without slight modifications in a number of books, and many students have doubtless come to regard the mammalian skull as a very simple structure compared with the skull of the reptile. It may perhaps be in part owing to this supposed simplicity that so many have rejected the idea of the mammal being descended from a reptilian ancestor. In the present paper, while I do not intend to discuss the question of the origin of mammals, I wish to show that most of the cranial bones which are supposed to be characteristic of the reptilian skull and absent in the mammal can really be found in one or other of the representatives of the mammalia. As there is to my mind no doubt that mammals are descended from some Therapsidan reptile, most probably a small Cynodont, I shall merely speak of the bones which are known to occur in the Therapsida, and which are not generally recognised in the mammalian skull.

Septomaxillary.

The septomaxillary bone was first discovered by Kitchen Parker in the skull of the lizard and snake, where it is of very large size. In 1900 it was found by Howes and Swinnerton in the skull of *Sphenodon*, and since then I have found it to be probably invariably present in Therocephalians and probably also in all Cynodonts though always absent in the allied Anomodonts. In the lizards and snakes the bone is specialised to serve as a roof and protection to the enormous organ of Jacobson, but in *Sphenodon* we find it in what is probably its primitive condition as a nasal floor bone. In Therocephalians and Cynodonts the relations of the bone have not been satisfactorily made out, but so far as is known it forms, as in *Sphenodon*, the floor of the anterior part of the nasal cavity and probably also protects the organ of Jacobson.

In mammals the organ of Jacobson is usually relatively small and well enough protected by its cartilage at the base of the septum. The nasal floor is also well protected by the secondary palate. There would consequently seem to be no use for a septomaxillary, and as might be expected it is almost invariably absent. About ten years ago, however, when working at the mammalian organ I came across a hitherto undiscovered bone in the floor of the nose of the Armadillo, *Dasypus villosus*. Though a description of the bone was published at the time, I was unable to come to any conclusion as to its homologies, and it was only when recently working at the organ of Jacobson in *Sphenodon* that I recognised that the septomaxillary of that reptile is essentially similar in its relations to the nasal floor bone of the armadillo. I therefore consider that the small bone in the nose of *Dasypus* is a true septomaxillary which has for some reason been retained from the reptilian ancestor. In *Dasypus villosus* there is a pair of crescentic bones, but in *Dasypus minutus* the bones are anchylosed together.

PREVOMER.

Some years ago I endeavoured to show that the paired bones in the front of the palate of the lizard which are usually called "vomers," are not homologous with the mammalian vomer. The vomer of the mammal is a median bone which forms as a splint on the basicranial axis. It may extend from the front of the axis to the basioccipital as in many Cetaceans, or it may be quite rudimentary, as in many rodents. In *Echidna* it is situated far back and does not appear in the anterior nasal region. In its relations and development it agrees exactly with the reptilian bone called "parasphenoid," as was pointed out first by Bland Sutton. The so-called "vomers" of the reptile are paired bones which have nothing to do with the basicranial axis, but develop as splints on the paraseptal cartilages, and principally serve as a protection to the organs of Jacobson. In *Ornithorhynchus* the paraseptal cartilages are protected by a pair of bones exactly as in lizards. These become anchylosed to form the "dumb-bell shaped bone" of the adult, but there can be little doubt that they are homologous with the so-called "vomers" of reptiles. As a new name was necessary for them I proposed to call them "prevomers."

In most mammals they are absent, their place being taken by the palatine processes of the premaxilla. In only one mammal besides *Ornithorhynchus* do I know of them occurring as distinct elements in the adult, viz., the bat *Miniopterus*. According to Kitchen Parker many Edentata and Insectivora have in fœtal life a pair of "anterior vomers," as he called them, supporting the paraseptals, but these early became anchylosed to the premaxillaries to form part of their palatine processes, though there can be little doubt that they are homologous with the prevomers of *Ornithorhynchus*. Prof. Cleland informs me that Goodsir was acquainted with a small bone occasionally present behind the premaxillary and in front of the vomer, and that in conversation he spoke of it as "John Arthur's bone." Most probably this was a prevomer which had appeared as an abnormality. *Gomphognathus* has a well-developed typical vomer and a pair of small prevomers.

PREFRONTAL, POSTFRONTAL, AND POSTORBITAL.

These three membrane bones which are all present in many reptilian skulls are not generally recognised as occurring in the mammalian skull, and in the very large majority of cases there is no trace of any of them. In Anomodonts and Therocephalians all three are probably always present, but one is usually very small. The bone which forms the upper part of the postorbital arch and passes back by the side of the parietal was formerly regarded as the postfrontal, but the presence of a small bone in front of it seems to show that it ought to be regarded as the postorbital, the small bone being the postfrontal. In the Cynodonts, though prefrontals and postorbitals are well developed, no postfrontals have hitherto been recognised, but as only very few good skulls have been examined it is probable that, as in the Anomodonts, all three bones will yet be recognised.

In *Tritylodon* there seems to be a distinct prefrontal and a bone behind the orbit which may be postfrontal or postorbital. Unfortunately the only known specimen is very imperfect, and there has been much discussion as to whether it is a mammal or a reptile, so that any evidence from *Tritylodon* does not at present carry very much weight. I have in a previous paper argued in favour of its being a mammal, and should this prove to be confirmed we shall probably have to admit the prefrontal at least as an element of the mammalian skull.

In *Ornithorhynchus* and *Echidna* there are at least two bones in the brain case which are not usually present in the higher forms.

These are named by van Bemmelen the "postfrontale (orbitosphenoidei)" and the "parietale-laterale." As both are apparently membrane bones it is likely that the anterior is the reptilian postfrontal and the posterior the postorbital. At the inner and anterior part of the orbit there is a bony plate which may be the prefrontal. It was believed to be so by Seeley, who apparently discovered it as a distinct element. Van Bemmelen does not apparently believe it to be distinct from the frontal, but in two of his illustrations he figures it as distinct. Until further work has been done to the structure of the skull in the young Monotremes the question of whether there is a distinct prefrontal must remain as not definitely settled.

QUADRATE.

I have elsewhere given reasons for believing that the mammalian quadrate became lost in the glenoid cavity, at least as a bone. In most mammals there is a distinct interarticular cartilage which may represent it, but in only one known mammal is there a bone. This is in *Pedetes*, the Cape-jumping hare. In it there lies in the front of the glenoid cavity a small flattened oval bone measuring 2 mm. × 1 mm. It is invariably present, but it is likely to be lost if the skull has been macerated. I regret that I have had no opportunity of examining the condition of the parts in the young animal, but hope to have ere long. It is just possible that the bone may prove to be something else than the quadrate, but it is difficult to see what else it can be. It may turn out to be a sesamoid bone in connection with the external pterygoid muscle, but as it is in the same position as the quadrate in the Cynodont reptiles the probability seems to be that it will prove to be a true quadrate bone.

There are evidences of one or two other bones in the mammal of interest. The ossicle of the caruncle in the young Monotremes is probably the internasal process of the premaxillary. I believe there is evidence of a distinct angular in the lower jaw of *Ornithorhynchus*, but this and some other points require further investigation.

NOTE ON THE LACERTILIAN SHOULDER GIRDLE.

By R. Broom, M.D., D.Sc.

(Read June 27, 1906.)

The shoulder girdle in the typical lizard is remarkable among reptiles for the peculiar anterior development of the coracoid and scapula. This anterior portion is for the most part cartilaginous and fenestrated. The structure was carefully examined and figured by Kitchen Parker in a number of lacertilian genera, and his views as to the nature of the parts have been largely followed by later writers. There are two large distinct bones which are pretty manifestly, in the main at least, scapula and coracoid, but the question to be decided is whether the cartilaginous anterior developments are to be regarded as unossified portions of the scapula and coracoid or as precoracoid or "epicoracoid." By Parker, and practically all writers since, the inferior cartilaginous margin of the coracoid is called the epicoracoid, and a portion of the anterior cartilaginous expansion the precoracoid. In the present short paper I wish to suggest that neither of these terms is justifiable, and that the shoulder girdle of the lizard consists of simply a scapula, coracoid, and clavicle on each side and an interclavicle between.

Some confusion has arisen with regard to the names epicoracoid and precoracoid. The former was, I believe, first applied to the anterior coracoidal element in the Monotremes, the latter to the anterior element in the Amphibians and primitive reptiles. It is now, however, pretty generally agreed that the anterior element of the Monotremes is homologous with the anterior cartilaginous bar in the Amphibia and with the anterior of the two ventral elements of the early reptiles, and therefore the same name ought to apply to both. Though "Epicoracoid" is apparently the earlier of the two names, only confusion would result from retaining it for the anterior coracoidal element, since, following Kitchen Parker, it has been almost constantly used in a different sense. Precoracoid is, on the other hand, well established as the name for the anterior element.

It seems to me inadvisable to give a special name to the inferior cartilaginous margin of the coracoid. In no animal is it ever a distinct bone. Most cartilage bones have their ends tipped with unossified cartilage, and even when a special ossification appears in the end cartilage it is only spoken of as an epiphysis. If phylogenetically reason could be shown for believing the cartilaginous tip to be the remains of an element once clearly distinct a special name might perhaps be given to it, but the name could not be "epicoracoid."

The primitive reptilian shoulder girdle consisted of three cartilage bones—scapula, coracoid, and precoracoid, and two membrane bones —the clavicle and cleithrum, with in the middle line an interclavicle. In only the most primitive reptiles and the Synapsida is the cleithrum met with, and very early in the Diapsidan phylum was the precoracoid lost. In no Diapsidan reptile is it known to occur after Permian times. Even in the very early *Palæohatteria* it is already lost—at least as on ossified element; and in *Sphenodon* there is no trace of it to be found in development. And there is good reason to believe that an element once lost in an ancestor can never be regained in a descendant. Various modifications may take place as in the ostrich, tortoise, plesiosaur, &c., but a distinct precoracoid never reappears. All the various anterior expansions of the scapula and coracoid in the typical lizard are likely to be only developments of the scapula and coracoid.

In the very aberrant lizard *Chamæleo* a peculiar condition of the shoulder girdle is met with, which strikingly recalls that of *Sphenodon,* and is possibly primitive. It is usually described as consisting of a narrow scapula and a rounded coracoid with no trace of a clavicle or interclavicle. In examining the embryo I have discovered that a fairly well-developed clavicle is present, best seen perhaps in an embryo, about one-fourth of adult size. There is no trace, however, of an interclavicle. Another point of interest is some indication of an acromion process in the lower end of the scapula passing a little further forward than the coracoid.

In the typical lizard the peculiar arrangement has probably arisen by the scapula and coracoid becoming expanded in an anterior direction, and at the same time the expanded part becoming fenestrated. This seems to be borne out both by the developmental condition and by the comparison of the different types found. As shown by Parker in *Laemanctus* only the coracoid is fenestrated by a single large opening. In *Psammosaurus* the scapula is but little expanded and quite primitive in type, while the coracoid is greatly expanded and has two large openings. In *Iguana*, on the other hand, both elements are greatly expanded and there are four large fenestræ.

In the embryo the scapula and coracoid are both originally unfenestrated cartilaginous structures, which, however, become fenestrated long before ossification begins. There thus seems good reason to believe that the lacertilian girdle is merely a highly specialised modification of the Sphenodon type and that it only contains the two cartilaginous elements—scapula and coracoid.

ON A NEW CYNODONT REPTILE (*ÆLUROSUCHUS BROWNI*).

By R. Broom, M.D., D.Sc., Victoria College, Stellenbosch.

(Read June 26, 1906.)

(Plate X.)

The fossil about to be described was discovered by Mr. Alfred Brown near Aliwal North, and represents the anterior part of a small Cynodont reptile. The remains are in a fairly hard sandstone, and, owing to the softness of the bone, cannot be very satisfactorily developed. Of the skull there are preserved a few remains of the cast of the upper cranial bones sufficent to give a satisfactory idea of the outline, and a very good impression of the palate showing the teeth. There are remains of the first twelve vertebræ, and a good deal of both scapular arches and of both anterior limbs. I propose to name the fossil in honour of the discoverer, who has spent so many years of his life in the interests of science, and who has already brought to light so many new forms.

Ælurosuchus Browni, g. et sp. nov.

Though the skull is badly preserved most of the important characters can be made out. The only previously described Cynodont which bears much resemblance to it is the type of *Microgomphodon oligocynus*, Seeley, but from this form it differs entirely in the dentition. As in *Gomphognathus*, *Microgomphodon*, and *Diademodon*, the skull is broad and flat. The orbits look for the most part upwards and are of large size. The temporal fossa is relatively small as in *Microgomphodon*, and measures more transversely than antero-posteriorly. The whole skull measures 92 mm. in length and 62 mm. in width. The parietal region measures about 10 mm. across. The postorbital arch is very narrow. The palate, which is fairly well preserved, is typically Cynodont, there being a well-developed secondary palate. The anterior part is apparently formed by the premaxillaries. In front of the large canines are two deep depressions for the lodgment of the lower canines. The region of the anterior palatine foramina is not well preserved. The secondary palate ends on the plane of the sixth molar.

The dentition of the upper jaw is fairly well shown, though the crowns of none of the teeth can be seen. There are five incisors, the first four being subequal and the fifth small. The five measure 9 mm. Six mm. behind the fifth incisor is the canine, which measures about 4 mm. × 3 mm. Following the canine are eight molars and premolars, all of relatively small size but increasing in size on passing backwards. The whole series measures 20 mm. Though not well preserved the teeth are evidently somewhat similar to those of *Trirachodon*, being broader than long.

A part of the brain case is preserved. The cerebrum is fairly large, and the cerebellum small. The mid-brain is also rather feebly developed. It is too imperfect, however, to enable one to say much of its affinities.

The vertebræ are very imperfect. The atlas is large, and the two halves of the arch apparently unanchylosed. The details of the later vertebræ cannot be made out satisfactorily. There are probably seven cervical vertebræ which measure about 65 mm. The following vertebra which is probably first dorsal has a long rib.

From the impressions and remains of the bones of the shoulder girdle the size and shape of both scapula and precoracoid can be made out, but there is no trace of the coracoid seen. The scapula measures about 56 mm. in length and it is probably similar in structure to that of *Cynognathus*. Ventrally it has a broad articulation with the precoracoid, which is large and flat and has a large rounded foramen.

The humerus is badly preserved but is possibly similar to that of *Gomphognathus*. It measures 20 mm. across the proximal end as preserved. The radius and ulna are badly preserved. They possibly measure about 50 mm. in length.

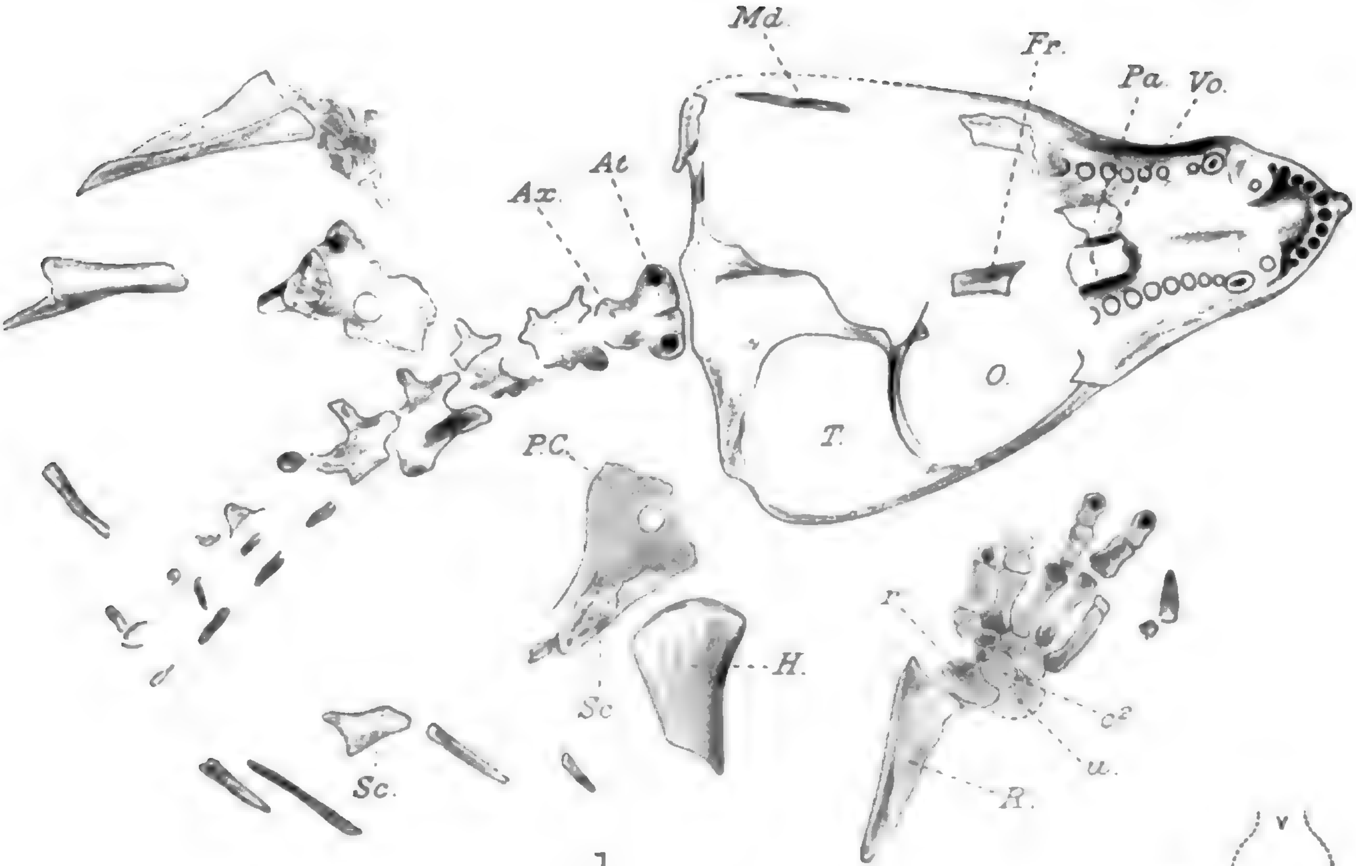
The carpus, though crushed on both sides, can be restored with some degree of probability. Carpalia 1, 2, 3, and 4, are well preserved. Above carpale 2 is a small element which I regard as centrale 1, and above carpale 2 is a larger element which is probably centrale 2. There is certainly a large radiale and large ulnare, and probably there is a fair-sized intermedium between. The bones of the proximal row are displaced in the right manus and imperfect in the left. I have given a restoration of what I believe to be the probable arrangement.

REFERENCE TO PLATE X.

Ac. acromion; *a.n.* anterior nares; *At.* atlas; *Ax.* axis; *cb.* cerebellum; *ce.* cerebrum; *Co.* coracoid; c^2, carpale 2; *D.* dentary; *Fr.* frontal; *Ju.* jugal; *Md.* mandible; *Mx.* maxilla; *Na.* nasal; *O.* orbit; *o.l.* optic lobes; *Pa.* palatine; *Par.* parietal; *p.co.f.* precoracoid foramen; *P.Co.* precoracoid; *Pmx.* premaxilla; *Po.O.* postorbital; *R.* radius; *r.* radiale; *Sc.* scapula; *Sq.* squamosal; *T.* temporal fossa; *u.* ulnare; *Vo.* vomer.

Fig.
1. General view of the remains of *Ælurosuchus browni* × $\frac{2}{3}$.
2. Restoration of skull × $\frac{2}{3}$.
3. Palate slightly restored. Nat. size.
4. Restoration of skull side view. Nat. size.
5. Cast of brain cavity. Nat. size.
6. Restoration of shoulder girdle. Nat. size.
7. Restoration of carpus. Nat. size.

Plate X.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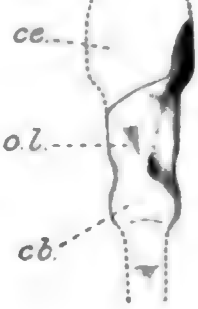

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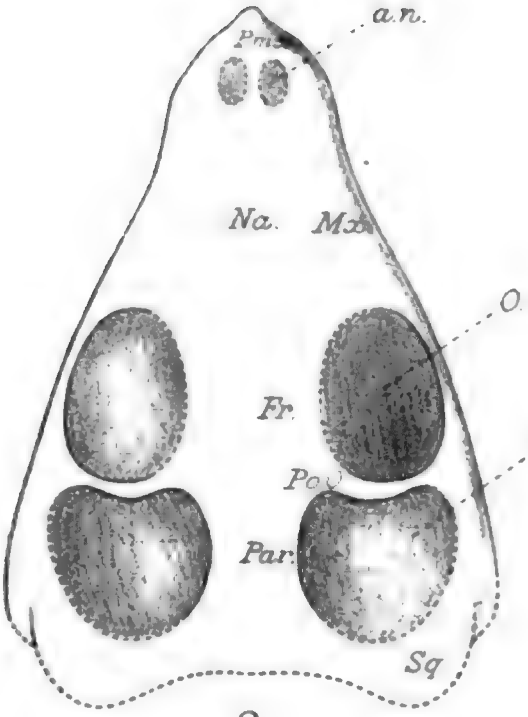
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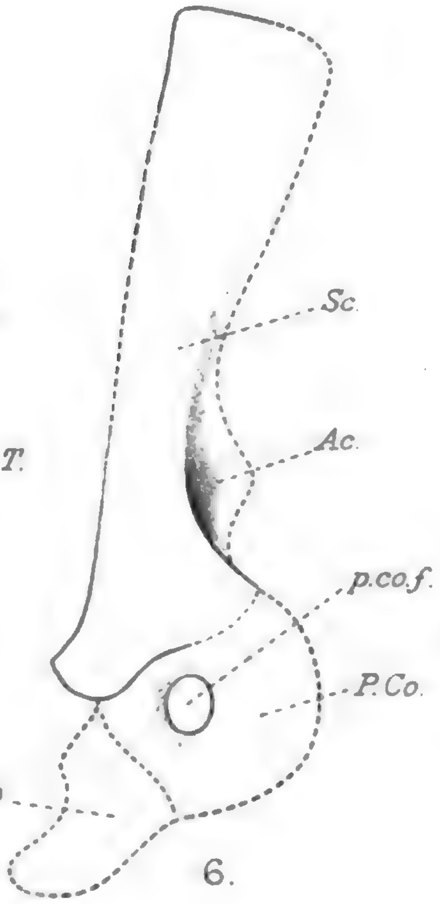
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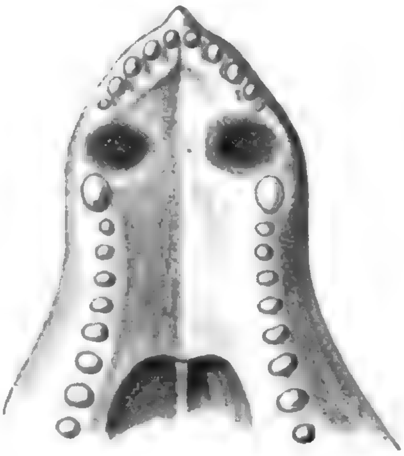

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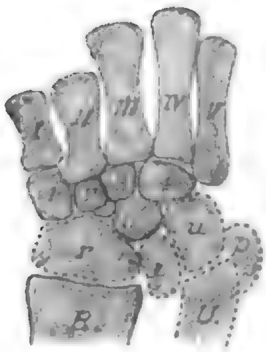
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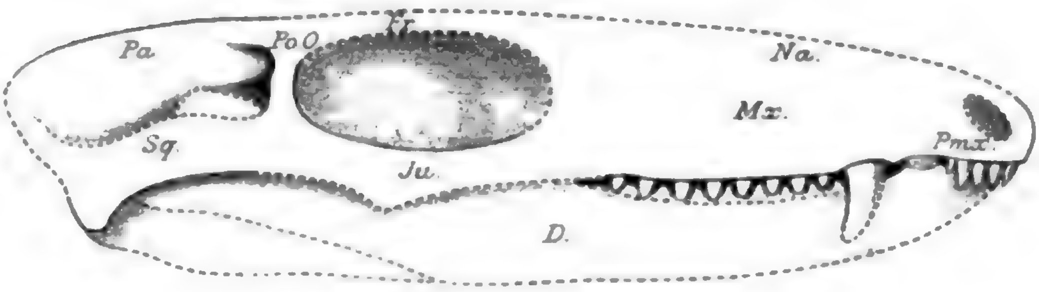
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4.

R. Broom del.

West, Newman lith.

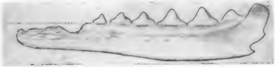
ÆLUROSUCHUS BROWNI, *Broom*.

ON A NEW SOUTH AFRICAN TRIASSIC RHYNCHOCEPHALIAN.

By R. Broom, M.D., D.Sc.

(Read June 27, 1906.)

In the collection of Mr. Alfred Brown, of Aliwal North, there is an imperfect lower jaw of a small reptile which is of considerable interest. The fragment represents the greater portion of the left dentary with six acrodont teeth of a slender lizard-like form which strikingly recalls the Jurassic *Homœosaurus*. As there are, even in the fragment preserved, one or two characters distinctly different from those of *Homœosaurus*, and as it is unlikely that the genus which is at present only known from the Kimmeridge occurred as early as the Trias, I propose to regard the African form as a member of a new genus and call it—



DENTARY OF PALACRODON BROWNI. × 3½.

Palacrodon Browni, n.g. et sp.

The dentary as preserved measures 19 mm., and it is unlikely that when perfect it measured more than 20 mm. In front it is very slender and though the teeth are lost it is probable that no part of the anterior third measured more than 2 mm. in depth. The first tooth preserved is situated 5·2 mm. behind the anterior part of the jaw. It is of very small size, measuring about ·8 mm. in length and about ·7 mm. in height. In this and the other teeth there is a sort of rudimentary cingulum at the base of the tooth, and the whole tooth stands out pretty markedly from the surface of the jaw. The first five teeth preserved increase steadily in size from before backwards, and the apices of the four following the first are situated at the following distances from the apex of the first—1·4, 2·9, 4·9, and 7 mm. respectively. The fourth tooth measures 2 mm. in length and 1·2 mm. in height; the fifth is 2 mm. in length and 1·5 mm. in height. Below the fourth and fifth teeth the jaw becomes much deeper than elsewhere, measuring 3 mm. Behind the fifth tooth is a smaller sixth tooth which is not very satisfactorly displayed but which is distinctly acrodont, showing that the jaw is probably that of an adult animal. Along the jaw, at a distance of 1 mm. from the base of the teeth, runs a low, longitudinal ridge probably for the attachment of the lip. At the posterior part of the specimen, the dentary passes upwards and curves very markedly inwards. There is no part of a coronoid bone preserved. From the shape of the back part of the dentary it seems probable that the planes of the two jaws sloped markedly inwards.

It is impossible from so small a fragment to say much of the animal, but it was evidently a form about half the size of *Sphenodon* and with much more slender jaws.

The deposit from which the specimen was obtained is a bone bed containing many fragments of bones and teeth, and it is possible that Mr. Brown's industry may yet be rewarded by other fragments which can be recognised as belonging to *Palacrodon*.

The specimen is of interest as being the earliest known true Rhynchocephalian. The Order Rhynchocephalia, which was formed for the reception of reptiles allied to Sphenodon, has been held by many to include the primitive types such as *Palæohatteria*, *Rhynchosaurus*, *Hyperodapedon*, and a number of others. By other authors it is held that if the order is expanded sufficiently to include the early types with plate-like pelvis, it becomes exceedingly difficult to define it and much confusion is likely to arise in forming the limits of the group. Following most American authorities I consider it advisable to restrict the group to those forms with two temporal arches and radiating pelvis—the *Rhynchocephalia vera* of others. This restricted group has hitherto not been known earlier than the Jurassic, but it might have been inferred to have originated in the Triassic. Our rich South African Triassic deposits will probably yield other types that will throw light on the origin of the group.

CONTRIBUTIONS TO THE AFRICAN FLORA.

BY HARRY BOLUS, D.SC., F.L.S.,

INCLUDING

Harpagophytum Pegleræ, by Dr. O. STAPF.
Selago swaziensis, by Mr. R. A. ROLFE.

(Plate XI.)

LOTONONIS SWAZIENSIS, *Bolus*, n. sp. (Leguminosæ-Genisteæ-Crotalariæ).

L. multifloræ proxima sed foliolis majoribus, bracteolis orbicularibus, floribus majoribus et in racemis paucioribus, facile distinguitur.

Fruticulus 30–60 cm. altus, undique, petalis flavis exemptis, argenteo-nitens; rami ramulique graciles, erecto-patentes, internodiis 0·5–1·5 cm. longis; folia alterna, exstipulata, petiolata, petiolis 0·2 cm. longis, 3-foliolata, foliolis obovato-cuneatis, emarginatis, apiculatis, 0·7–1·3 cm. longis, 0·4–0·6 cm. latis; racemi terminales, sæpissime 3–, rarius 1–2-fl., bracteis caducis; pedicelli 0·2 cm. longi, bracteolis 2, orbicularibus, valde concavis, apiculatis, 0·5 cm. longis et latis; calyx inflatus 0·8 cm. longus, labio superiore perbrevissime 4-dentato, segmento inferiore deltoideo, acuminato, 0·2 cm. longo; vexillum reflexum, subrotundum, breviter unguiculatum, externe pilosum, 1·2 cm. longum 1 cm. latum; alæ obovatæ, apice rotundatæ, lamina 0·6 cm. longa et lata, ungue 0·6 cm. longo; carina acuta, lamina 0·5 cm., ungue 0·6 cm. longo; legumen sessile, oblique oblongum, subturgidum, 1·5 cm. longum, 0·4 cm. latum, seminibus 5–6.

HAB.: Swazieland; grassy hills and valleys, Dalriach, near 'Mbabane, Jan., approx. alt. 1,350–1,450 meters, *H. Bolus*, 11766.

INDIGOFERA SWAZIENSIS, *Bolus*, n. sp. (Leguminosæ-Galegeæ-Indigoferæ. § Productæ).

Ad I. cylindricam accedit sed indumento, pedicellis brevioribus, bracteis longioribus, differt.

Suffrutex ramis adscendentibus, striatis, cum petiolis, stipulis, nerviis primariis, pedunculis, calyce et vexillo brunneo-pubescentibus, internodiis 2–2·5 cm. longis; folia petiolata, petiolo 1 cm. longo, imparipinnata, foliolis sæpissime 7–8, rarius 4–6-juga, petiolulatis, minute stipellatis, ovalibus, apiculatis, strigillosis, 1–2 cm. longis, 0·7–1·2 cm. latis, rhachi 6·5–7·5 cm. longa; stipulæ setaceæ, 1 cm. longæ; pedunculi 2–2·5 cm. longi, racemis densis, 4–6 cm. longis; flores pedicellati, pedicellis 0·2 cm. longis; calyx 0·3 cm. longus, subæqualiter 5-lobus, lobis deltoideis, acuminatis; vexillum late ovatum, apice rotundatum, sessile, intus glabrum, 0·9 cm. longum, 0·6 cm. latum; alæ oblongæ, obtusæ, brevissime unguiculatæ, 0·6 cm. longæ, 0·2 cm. latæ; carina obtusa, vexillum subæquans; stylus basi villosus; ovarium 7–8-ovulatum, glabrescens; legumen?

HAB.: Transvaal; Schlechter 3908! near Lydenburg, Jan., Wilms 327 (in herb. Kew & Brit. Mus.), 315 (in herb. Brit. Mus.); *Swazieland;* grassy places, Dalriach, near 'Mbabane, Dec., approx. alt., 1,450 meters, *H. Bolus*, 11804.

VIGNA DAVYI, Bolus, n. sp. (Leguminosæ-Phaseoleæ-Euphaseoleæ).

V. omnibus partibus (petalis exemptis) hirtis; foliis simplicibus. Ad quasdam formas V. vexillatæ accedit.

Tota planta nisi petala plus minusve aspera villis brunneis; rami procumbentes, patentes; folia simplicia, ovata vel late lanceolata, acuta, basi rotundata, petiolata, petiolis 1–1·5 cm. longis, multireticulata, nerviis primariis 3, adscendentibus, inferne prominentibus, 10–12 cm. longa, 4–8 cm. lata; stipulæ oblique ovato-lanceolatæ, longe acuminatæ basi cordatæ, multi-nervatæ, 1 cm. longæ; stipellæ lanceolatæ, acuminatæ, 0·6–0·7 cm. longæ; pedunculi axillares, robusti, arcuato-erecti, 10–21 cm. longi, biflori, floribus subsessilibus; bracteæ lanceolatæ, cum bracteolis linearibus acuminatis, 0·8 cm. longæ; calyx campanulatus, subæqualiter 5-fidus, tubo 0·8 cm. longo, segmentis lanceolatis, setaceo-acuminatis ca. 1 cm. longis; vexillum late reniforme, emarginatum, 2·1 cm. longum, 3·4 cm. latum; carina valde incurva, rostrata, 2·1 cm. longa; stigma laterale, bilabiatum, labio superiore cucullato, inferiore bilobo, patentes, margine dense piloso; ovarium dense fusco-villosum.

HAB.: *Swazieland;* near Mbabane, *J. Burtt-Davy*, 2827 (in Herb. Brit. Mus.); "High Veld" between Carolina and Dalriach, approx. alt., 1,700 meters, Dec., *H. Bolus*, 11836.

Uganda; mouth of the Kagera River, *Bagshawe* (in Herb. Brit. Mus.).

DOLICHOS ROBUSTUS, Bolus, n. sp. (Leguminosæ-Phaseoleæ-Eu-phaseoleæ).

D. foliis majoribus, labio inferiore calycis profunde 3-fido, segmentis elongatis.

Robusta, tota, petalis exceptis ± pubescens; rami procumbentes quadrangulares, striati, foliosi, internodiis 3·5–5·5 cm. longis; folia tactu asperula, petiolata, petiolo communi, 3–4 cm. longo, internodio 1·5–2 cm. longo, foliolis lateralibus a ramo 2–2·5 cm. distantibus, circumscriptione obovatis, basi subcuneatis, impariter bilobis, lobis subacutis mucronulatis, nervis prominulis, 4–5·5 cm. longis, 2·5–4 cm. latis, foliolum terminale obovatum æqualiter 3-lobum, 6–7·5 cm. longum, 6–7 cm. latum, ceteroquin lateralibus conformibus; stipulæ obliquæ lanceolato-ovatæ, acutæ, nervatæ ad 1 cm. longæ; stipellæ lineares setaceo-acuminatæ, 0·6 cm. longæ; pedunculi axillares ad 1·5 cm. longi, bracteis lanceolatis, acutis 0·2–0·4 cm. longis, 2–4-fl., pedicellis 0·4 cm. longis; calycis labio superiore bidentato, inferiore subæqualiter profunde 3-fido, segmentis lanceolatis acuminatis 0·5 cm. longis, tubo subinflato 0·5 cm. longo, 0·4–0·5 cm. lato; vexillum suborbiculare, basi auriculatum, 1·2 cm. long et lat.; alæ oblique oblongæ obtusæ, basi calcare 0·3 cm. longo, instructæ; carina oblonga obtusa leviter incurva, alas vexillumque subæquans; ovarium sericeo-villosum; legumen deest.

HAB.: Transvaal Colony; on the "High Veld" between Carolina and Swazieland, in grassy places, approx. alt., 1,550 meters, Dec., *Bolus*, 11837.

Rather remarkable in the genus by its robustness and large leaves, and by the deeply cleft lower lip of the calyx.

DOLICHOS FALCATUS, *Klein.*

This plant, a native of India, does not yet appear to have been recorded from South Africa, nor is it mentioned by Oliver and Hiern in the Flora of Tropical Africa. The following collections may be cited: Cape Colony: Komgha, *Flanagan*, 1141! Transvaal: Barberton, *Galpin*, 753! Lydenburg, *Wilms*, 412! Pretoria, *Bolus*, 11840! Warm Bath, *id.*, 11839!

RHYNCHOSIA PAUCIFLORA, Bolus, n. sp.

R. foliolis longis angustisque; floribus solitariis, axillaribus, pedunculatis; calyce corollam æquante vel excedente, segmentis prominenter 1-nervis.

Fruticulus erectus, undique plus minusve sparse pilosus, ca. 30 cm. altus; rami adscendentes, graciles, internodiis 2·5–3 cm.

longis; folia alterna erecta petiolata, petiolo 0·7–0·8 cm. longo, foliolis linearibus, apice basique angustatis, mucronulatis, marginibus reflexis, superne delicate reti-venosis, pallidioribus, inferne nervo medio valde prominente, 6–7 cm. longis, 0·4–0·5 cm. latis; stipulae subulatæ, longe acuminatæ, 0·8–0·9 cm. longæ; pedunculi axillares, patentes, graciles, 5–6 cm. longi, apicem versus articulati, ad articulum bracteola setacea 0·4 cm. longa ornati; calyx campanulatus, persistens, segmentis lanceolatis, acuminatis, subæqualibus, nervo medio perspicuo, superioribus usque ad medium connatis, inferioribus fere ad basin liberis, corollam æquantibus vel sæpius excedentibus; vexillum glabrum, carina æquilongum, 1·3 cm. longum; legumen oblique ovatum pilosum 2-spermum, stylo persistente desinens, 3 cm. longum, 0·8–1 cm. latum.

HAB.: Transvaal Colony, in grassy places, "High Veld," near Carolina, approx. alt. 1,790 meters, Jan., *Bolus*, 11842 (in herb. Kew, my own, &c.).

METALASIA PALLIDA, Bolus, n. sp. (Compositæ-Inuloideæ

M. aduncæ affinis, sed foliis nec uncinatis, capitulis 10-*fl.*, *involucri squamis petaloideis* 2–3-*seriatis.*

Suffrutex erectus, totus pallidus, 25–30 cm. altus; rami adscendentes, cano-tomentosi, vel vetustiores glabrescentes, internodiis 0·2–0·3 cm. longis; folia sparsa, erecta, lineari-lanceolata, mucronata, stricta nec torta, involuta, inferne glaberrima, nitentia, obscure 1-nervia, axillis nudis, 0·7–1 cm. longa, 0·2–0·3 cm. lata; corymbus confertus, pedunculis 0·2–0·3 cm. longis, capitulis discretis 12–20, cylindricis, 0·8–1 cm. longis 0·3–0·4 cm. latis; involucri squamæ exteriories 3–4-seriatæ, appressæ, lineares, acuminatæ, sphacelato-mucronulatæ, araneosæ, 0·2–0·5 cm. longæ, interiores petaloideæ, 2–3-seriatæ, erectæ, obtusæ, apice concavæ, albæ, 0·6–0·7 cm. longæ, 0·1–0·2 cm. latæ; achænia tereti-subtriangularia, glabra, punctulata, 0·2 cm. longa; pappi setæ capillaceæ, barbellatæ, albæ.

HAB.: Cape Colony; Prince Albert Division; on the Zwartebergen, near Zwartberg Pass, in rocky places, approx. alt. 1,080 meters, Dec., *H Bolus*, 11542 (in herb. Kew, my own, &c.).

METALASIA STRICTIFOLIA, Bolus, n. sp. (Compositæ-Inuloideæ).

M. aduncæ proxima, sed foliis erectis, strictis nec uncinatis, axillis gemmiferis, distinguitur.

Fruticulus ramosissimus, fere undique araneoso-tomentosus, 15–20 cm. altus; rami adscendentes, conferti, 4–7 cm. longi; folia sparsa, erecta, lineari-lanceolata, pungenti-mucronata, araneosa, deinde vel pilosa, vel rarius glabrescentia, sæpissime axillis gemmiferis, 0·5–0·9 cm. longa; capitula 5–10-glomerata, glomerulis 1–1·5 cm. latis, discreta nec indumento intertexta, cylindrico-campanulata, 5-fl., 0·9 cm. longa, apice 0·2–0·4 cm. lata; involucri squamæ exteriores 3-seriatæ, appressæ, lanceolatæ, acuminatæ, mucronulatæ, 0·3–0·6 cm. longæ, petaloideæ 1-seriatæ, patentes, lineares, obtusæ, albæ, flores excedentes, 0·8 cm. longæ, 0·2 cm. latæ; pappi setæ copiosæ, filiformes, serrulatæ, albæ, longitudine inter flores et squamas petaloideas intermediæ.

HAB.: Cape Colony; Prince Albert Division, on the summit of the Zwartebergen, near Zwartberg Pass, in rocky places, approx. alt. 1,850 meters, Dec., *H. Bolus*, 11990 (in herb. Kew, my own, &c.).

BOJERIA NUTANS, Bolus, n. sp. (Compositæ-Inuloideæ).

B. foliis basi auriculatis; capitulis axillaribus solitariis, nutantibus.

Frutex erectus, 5-pedalis, undique scaberulus; rami virgati, striati, internodiis 2–2·5 cm. longis; folia adscendentia, ovato-lanceolata vel lanceolata, acuta, basin versus angustata, semi-amplexicaulia, late auriculata, serrata, nerviis primariis subtus prominentibus, adscendentibus, utrinque 7–8, subtus pallidiora, 5–13 cm. longa, 2–4 cm. lata; pedunculi solitarii in axillis foliorum superiorum, nutantes, graciles, 4–6·5 cm. longi, bracteolis foliaceis, 3–4, lanceolatis, sub capitulo approximatis, circa 1·5 cm. longis; capitula cyathiformia, 2 cm. longa, 2·5 cm. lata; involucri squamæ 4-seriatæ, lanceolatæ, intimis linearibus, acuminatissimis, flores acquantibus, herbaceæ, virides, marginibus submembranaceis, sericeo-ciliatis, apicibus barbatis, discoloribus, 0·5–1·5 cm. longæ; corollæ cylindricæ, 1·1 cm. longæ, limbo 0·15 cm. longo; styli rami insigniter atro-brunnei; achænia glanduloso-pubescentia, 0·3 cm. longa, setis pappi barbellatis, persistentibus, extimis brevissimis, intimis corollam æquantibus.

HAB.: Orange River Colony; Witzie's Hoek, grassy slopes near the summit of Mapedi's Peak, approx. alt. 2,650 meters, Feb., *Justus Thode* 21!; Basutoland, river banks above Buffalo River Waterfall; approx. alt. 2,500 meters, March, *E. E. Galpin, 6659!*

PEGOLETTIA DENTATA, Bolus, n. sp. (Compositæ-Asteroideæ).

P. foliis oblongis, grosse dentatis, pappo biseriato exteriore e setis pluribus brevissimis, interiore e setis 5–7 *multo longioribus barbellatis.*

Fruticulus humilis erectus ramosus, parce brevissimeque glanduloso-puberula; rami pauci divaricati, rigidi inferne nudi, sursum nunc pauce nunc dense foliati, vetustiores cicatricibus

foliorum delapsorum notati, 10–15 cm. longi, inferiores 0·2 cm. crassi; folia oblonga acuta, basi valde attenuata, utraque dentibus grossis 2–3 acutis aucta, minute glanduloso-puberula, viridia, 1–2 cm. longa, 0·15–0·2 cm. lata; capitula terminalia solitaria campanulata, 1·5 cm. longa, 2 cm. lata, 100-fl. vel ultra, in pedunculis bracteatis 0·75–1·25 cm. longis, bracteis paucis parvis subulatis subscariosis; receptaculum foveolatum; involucri squamæ 4–5-seriatæ numerosissimæ recurvo-patentes subulatæ, longe setoso-acuminatæ, integræ nudæ 1-nervæ, scariosæ pallidæ, omnibus inter sese subæqualibus ± 1 cm. longis; corollæ tubulosæ, regulariter 5-fidæ tenuissimæ, 0·8–0·9 cm. longæ; pappus biseriatus e setis exterioribus brevioribus pluribus, 0·1 cm. longis, cum setis 5–7 interioribus barbellatis longioribus, 0·8–1 cm. longis; ovaria dense albo-sericea 0·15 cm. longa.

Hab.: Cape Colony; district Montagu, near the warm baths, on dry rocky hills, alt. 300 meters, Dec. (1892), *Bolus*, 7882 (in herb. Kew and my own).

In floral structure nearest to *P. oxyodonta DC.*, but differing in pappus and very much in habit and general appearance, being smaller in all parts, greener, and nearly glabrous. It appears to be rare.

Chrysanthellum procumbens, *Pers.* (Helianthoideæ-Coreopsideæ).

This widely-spread tropical species, probably a native of the East Indies, has long since been found in various parts of Tropical Africa, from Abyssinia southward. It occurs near Bulawayo, specimens having been sent by Rev. A. Barthelemy from that town. Finally, it was collected by me at Warm Bath in the Transvaal Colony in January last (Bolus, 12090), and this seems to be the only extra-tropical station yet recorded for it.

Phæocephalus gnidioides, *S. Moore in Journ. Bot.* (1900), p. 158, t. 409 (Compositæ-Anthemideæ).

This species was first found by F. Masson, who travelled in the Cape Colony in 1775, and the single specimen he sent to England lay *perdu* in the herbarium of the British Museum until it was examined, and the genus established, by Mr. Moore as above. This gentleman was good enough to draw my attention to it when in England two years ago, in the hope that I might be able to find it again, no other specimen being known. As no station had been recorded by Masson, it was therefore a singular coincidence that a few months after my return to the Colony I found the plant when

crossing the Zwartberg Pass from Prince Albert. It grows in some abundance on the left side of the road about 2 or 2½ miles from the summit of the Pass, on the Prince Albert side of the mountain. The bush is of straggling habit, 2–3 ft. high, with its branches nude below, flowers yellow, with the aspect of an Athanasia. The rediscovery of the species after a lapse of 130 years appears sufficiently interesting to be worthy of record.

ATHANASIA THODEI, Bolus, n. sp. (Compositæ-Anthemideæ).

A. foliis linearibus sæpius indivisis rarius 2–3-fidis intermixtis, corymbis polycephalis dense confertis, capitulis hemisphericis, 35–40-floris ; involucri squamis subbiseriatis, achæniis pappo minuto denticuliformi coronatis.

Suffrutex 4–5-pedalis, subviscidus, odore aromatico. Rami erecti vel patentes, ad 20 cm. longi, 0·5 cm. crassi, nudi, asperi, cinerei ; ramuli 8–10 cm. longi, albo-tomentosi, usque ad apicem foliosi, inferne nudi ; folia juniora erecta, demum recurvo-patentia linearia indivisa vel interdum supra medium 2–3-fida, obtusa, superne glabra, aspera, subtus tomentosa prominenter 1-nerva, 2–3 cm. longa 0·1–0·15 cm. lata ; capitula hemispherica, 0·3–0·4 cm. longa, 35–50-flora, in corymbo dense polycephalo, 2–3 cm. lato, conferta, pedicellis bracteatis ; involucri squamæ subbiseriatæ appressæ lanceolatæ, acuminatæ, scariosæ, sæpe laceratæ, extus tomentosæ exterioribus longioribus flores æquantibus ; receptaculi paleæ lanceolatæ acuminatæ apicem versus serrulatæ, floribus paullo brevioribus ; corolla 0·25 cm. longa ; achænia tenuia striata glabra, pappo e squamis 5 denticuliformibus acutis minutissimis coronata.

HAB. : Natal ; stony places near the summit of the Mont-aux-Sources, alt. 2,800 meters, Jan. (1896), *Justus Thode*, 23 ! Cape Colony ; district Barkly East, Doodman's-Krantz-Mt., 2,800 meters, March, *Galpin*, 6707 ! (in herb. Kew, my own, &c.).

Thode's plant has longer undivided leaves, larger corymbs and smaller heads ; those of Galpin show several bifid and trifid leaves, intermixed with undivided and mostly shorter leaves, smaller corymbs with fewer and larger heads; the measurements given above represent the extremes of size. The species does not greatly resemble any other known to me.

EUMORPHIA DAVYI, Bolus, n. sp. (Compositæ-Anthemideæ).

E. foliis linearibus integris glabris, viridibus ; involucri squamis intimis apice ovatis membranaceo-dilatatis.

Tota glabra ; rami lignosi adscendentes dense foliosi, 18 cm. longi ;

folia sparsa conferta imbricata, adscendentia vel patentia, linearia acuta mucronulata, pleraque curva, viridia, 1–1·2 cm. longa, 0·06–0·07 cm. lata; capitula terminalia solitaria subsessilia, obconica vel transverse semi-ovata, basi angustata, radiis exemptis 0·5–0·6 cm. longa, apice 0·6 cm. lata; involucri squamæ multiseriatæ, appressæ, imbricatæ, exterior ibus brevissimis, intermediis, lanceolatis acuminatis laceratis, apicem versus membranaceis, 0·6 cm. longis, intimis apice in laminam ovatam membranaceam discolorem dilatatis, 0·7 cm. longis; flores radii 12–14, patentes, ligulis oblongis 3-dentatis, 0·7 cm. longis, disci numerosi.

Hab.: Transvaal Colony; district Lydenburg, Graskop near Pilgrim's Rest, on the edge of the Drakensbergen, Jan., *J. Burtt-Davy*, 1474! (in herb. Kew, my own, &c.).

This species is very distinct and unlike any other in its foliage. The membranous dilatation of the tips of the inner involucral scales is also larger than in any other.

EUMORPHIA PROSTRATA, Bolus, n. sp. (Compositæ-Anthemideæ).

E. prostrata, ramis radicantibus, foliis plerisque indivisis, hinc inde bifidis albo-sericeis, receptaculum paleis paucis tantum sub floribus exterioribus auctum.

Fruticulus prostratus, ramis radicantibus nudis, glabris, ad 25 cm. longis, ramulis foliosis patentibus, 2–6 cm. longis; folia subdensa, juniora fasciculata, incurva vel recurva, sessilia, linearia vel spathulato-linearia acuta; pleraque indivisa hinc inde bifida, basi connata, pubescentia albo-sericea arcte appressa nitente vestita, 0·6–1 cm. longa, 0·1–0·15 cm. lata, suprema abbreviata in bracteas foliaceas usque ad basin capitulorum abeuntia; capitula terminalia, solitaria, hemisphærica, brevissime pedunculata vel subsessilia, 0·65–0·8 cm. longa, 0·6–0·7 cm. lata; involucri squamæ 3–4-seriatæ, erectæ, exterioribus brevioribus deltoideis interioribus lanceolatis oblongisque omnibus acutis albo-sericeis; receptaculum paleis paucis præcipue sub floribus exterioribus auctum; flores radii 10–14, ligulis patentibus reflexisve, oblongis albis, 0·6–0·7 cm. longis, flores disci numerosi flavi; ovaria immatura glabra.

Hab.: Cape Colony; district Barkly East, summit of Doodman's-Krantz-Mt., approx. alt. 2,800–2,970 meters, March 8, 1904, *E. E. Galpin*, 6700! (in herb. Kew, my own, &c.).

This comes near to *E. sericea Wood & Evans*, but is distinguished by its prostrate habit, shorter, more appressed and shiny indument, and its smaller heads with shorter rays. The paleæ on the receptacle in the head examined are very few.

Senecio thermarum, Bolus, n. sp. (Compositæ-Senecionideæ).

S. ambifario Sp. Moore, proximus, sed pedunculis solitariis, floribus numerosioribus, foliis brevioribus differt.

Herba annua, erecta, tota pallida, cum pedunculis ca. 25 cm. alta; rami adscendentes, foliosi, ad 9 cm. longi, internodiis 0·3–0·4 cm. longis; folia sessilia, erecto-patentia, oblanceolata, acuta, obscure nervata, membranacea, juniora araneosa, demum glaberrima, 3–4 cm. longa, 0·8–1 cm. lata; pedunculi terminales, solitarii, graciles, nudi, leves, apice paullo dilatati, 20 cm. longi; capitula campanulata, homogama, discoidea, 1 cm. longa; 0·8 cm. lata; involucri squamæ 8, oblongæ, deltoideo-acutæ, marginatæ glaberrimæ, 0·6 cm. longæ, 0·15–0·2 cm. latæ; flores ca. 23 albi, corollis medio abrupte dilatatis, 0·6 cm. longis, segmentis acutis, papillosis; ovaria teretia, apice truncata, 4 striata, striis scabris.

Hab.: Transvaal; Waterberg District; among shrubs near Warm Bath, approx. alt. 1,150 meters, Jan., *H. Bolus*, 12034; Boschveld, Klippan, *Rehmann* 5241! Delagoa Bay Collection, *Schlechter*, 11727 (precise station not available).

Euryops Gilfillanii, Bolus, n. sp. (Compositæ-Senecionideæ).

E. acaule, foliis radicalibus gramineis, scapo monocephalo.

Rhizoma breve sublignosum, lana sordida cum reliquiis foliorum delapsorum coronatum; folia omnia radicalia erecta linearia vel marginibus involutis sæpe filiformia, plerisque indivisis hinc inde paucis bifidis trifidisque, obtusa, rigida, glabra, apice sphacelata, basi dilatata, scariosa, multinervia, pallida, 6–12 cm. longa, 0·1 cm. lata; scapus solitarius gracilis, monocephalus, nudus, glaber, 18–30 cm. longus; capitulum hemisphericum, 0·4–0·5 cm. diametro. Involucri squamæ 9–11, ovato-lanceolatæ acutæ vel acuminatæ, infra medium connatæ, glabræ; flores radii 9–10, ligulis patentibus 0·4 cm. longis, disci numerosissimi; ovaria ovoidea, puberula.

Hab.: Transvaal Colony; district Middelburg, near Witbank Railway Station, Dec., *D. F. Gilfillan* (No. 7201 of Mr. Galpin's distribution! in herb. Kew, my own, &c.).

In habit this is very different from any of the genus known to me, more resembling that of some of the stemless Othonnæ. The approximate altitude of the station is not given by the collector, and I have no data at hand to refer to. It is in what is so well known as the "High Veld" of the Transvaal, and probably between 5,000 and 6,000 ft. above the sea. There are numerous coal-mines in the vicinity.

EURYOPS GALPINII, Bolus, n. sp. (Compositæ-Senecionideæ).

E. foliis lanceolatis integris ; capitulis terminalibus solitariis vel binis, sessilibus ; involucri squamis circa 12, *ultra medium connatis ; radii flosculis* 12-15, *disci* 50 ; *achæniis clavatis, glabris.*

Suffrutex glaber, 2–3-pedalis; rami adscendentes, superiores foliosi, inferiores nudi cicatricibus foliorum delapsorum notati ; folia dense conferta usque ad basin capitulorum, imbricata, sessilia, recurvo-patentia, oblongo-lanceolata subacuta cartilagineo-ciliolata, subtus nervo valido percursa, 0·7–0·9 cm. longa, 0·2–0·28 cm. lata ; capitula terminalia, in pulvillo tomentoso sessilia, foliis floralibus parum dilatatis arcte cincta, turbinata 1–1·1 cm. longa ; involucri squamæ circa 12, ultra medium connatæ, cartilagineæ, leves, pallide flavæ, segmentis late lanceolatis minute ciliolatis ; receptaculum foveolatum; radii flosculi 12–15, ligulis 1·4 cm. longis, disci circa 50, 0·45 cm. longi, concolores, lineis 5 purpureis notati, segmentis lineari-lanceolatis acutis ; achænia clavata, glabra, polita, 0·24 cm. longa ; pappi setæ breves, barbellatæ.

HAB. : Cape Colony ; district Queenstown, on Hanglip Mt., alt. about 1,850 meters, Nov., *E. E. Galpin*, 1620 ! on the Windvogelberg, 1,400 meters, June, *Rev. Baur*, 1117 ! (both in herb. Kew).

This has the habit and general appearance of *Gamolepis brachypoda DC.*, with similarly closely imbricated leaves ; but their shape is quite different, and the heads in this are sessile, or nearly so.

LASIOCOMA, Bolus, gen. nov. (Compositarum e tribu Senecionidearum).

Ex affinitate Euryopis a quo differt achæniis fl. ♀ *sterilibus pappique in fl.* ♀ *defectu.*

Capitula heterogama radiata, floribus radii ♀ , 1-seriatis fertilibus, disci ☿ sterilibus. Involucrum campanulatum, bracteis 1-seriatis, subæqualibus, usque ad medium fere in cyathum connatis demum subsolutis liberisve patentibus. Receptaculum planum, alveolatum, septis elevatis dentibus paleæformibus acuminatis auctis. Fl. ♀ : corollæ ligulatæ, lamina patente, parva, 3-dentata ; achænia clavata, a dorso compressa, lana densa alba accrescente demum longissima vestita, calva. Fl. ☿ : Corollæ regulares, tubulosæ, limbo subinfundibuliformi apice 5–fido ; antheræ basi integræ obtusæ ; styli rami applanati, subtruncati, penicillati ; achænia tenuia, vacua, breviter pubescentia pappo e satis barbellatis 1-seriatis numerosis coronata. —Fruticulus erectus ramosus, glaber, 2–3-pedalis. Folia alterna patentia, e basi semiamplexicauli linearia, ultra medium 3-fida, lobo intermedio integro, lateralibus linearibus 2-fidis, 2-lobisve, omnibus

apice calloso-mucronulatis. Pedunculi axillares, solitarii, graciles, foliis sæpius longiores. Involucri squamæ 6–7, subæquales, oblongæ subacutæ. Flores radii 6–7, disci 9–12 (ut videtur ex siccis, flavi).

Lasiocoma petrophiloides (DC.), Bolus; sp. unica. *Eriocephalus ? petrophiloides DC., Prodr.* vi. 146; *Harv. & Sond., Flora Capensis*, iii., 201.

Folia 1·5–2·5 cm. longa, segmentis 0·07–0·1 cm. latis; pedunculi 1·5–2·5 cm. longi; capitulo cum lana achæniorum, 0·8–1·1 cm. longa; involucrum 0·45–0·7 cm. longum; radii ligulæ 0·35 cm. longæ; pappi setæ fl. ☿ 0·2 cm. longæ; achænia fl. ♀ 0·5 cm. longa.

Hab.: South Africa, without station, *Drège; Ecklon*, 446 (in herb. Sonder). Cape Colony: Nama'land Minor, near Klipfontein, in open places, alt. 950 meters, Sept. (1883), *Bolus*, in MacOwan & Bolus, herb. Norm. Aust.-Afr., 426 (in herbb. Kew, Brit. Mus., Paris, Berlin, &c.); Calvinia Division, near Nieuwoudtville, *C. L. Leipoldt*, 760! "Very common, growing in sandy soil in big patches, fl. May to Oct., and said to be a very fine 'sheep-bush'" (Collector's note).

The affinity of the genus is clearly with Euryops, from which it is separated by the sterile achenes of the disk and by the absence of pappus on the ♀ flowers. The remarkably long accrescent hairs on the achenes of the ♀ flowers are a further peculiar character; for while the achenes of Euryops are commonly villous, there is nothing in that genus, so far as known to me, approaching those of this plant, which led De Candolle and Harvey to suppose that it might be an Eriocephalus.

The present plant has a rather singular history. First found by Drège and by Ecklon, it was described by De Candolle in 1837 (*loc. cit.*); but so imperfect were the specimens that he expressed much doubt as to the genus. Harvey, in 1864, had both Drège's and Ecklon's specimens before him, yet fared no better. He followed De Candolle in placing them, with doubt, in Eriocephalus, but says: "A most remarkable species, unlike any other, and possibly not of this genus; but the fl.-heads, in the only specimens I have seen, have had their contents eaten by insects, leaving merely the outer invol. and a dense tuft of discoloured wool. What may be the origin of this wool, whether from an inner invol. or from the achenes, remains undetermined." In 1883 the plant numbered 426 in the Herb. Norm. Austro-Africanum was found by me, and being deceived by the similarity of the involucre was distributed by me, without having dissected it, as a Euryops. A more recent examination appeared to show its distinctness from that genus, and a reference to the description of *Eriocephalus petrophiloides DC.* seemed to leave little doubt as to its identity with that species. By the kindness of M. Casimir de Candolle, of Geneva, who has compared my plant with the type in the "Prodromus herbarium," this probability has been rendered a certainty. The plant has since been collected by Mr. C. L. Leipoldt, whose notes on his ticket are interesting; a bush which seems to be as attractive to sheep as it certainly is to insects (for a large proportion of all the flower-heads seen have been attacked) must have a hard struggle for existence.

Plate XI., fig. 1, Involucre; 2, ♀ flower, the ovary deprived of its wool; 3, ☿ flower; 4, stamens; 5, a hair of the pappus from the ☿ flower, × 30; 6, mature achene of the ♀ fl., with wool and half-concealed corolla, × 2; 7, mature achene of ♀ fl., deprived of its wool, × 4; 8, section of ditto; 9, style branches of the ☿; 10, ditto of the ♀ fl.; 11, receptacle.

GAMOLEPIS INTERMEDIA, Bolus, n. sp. (Compositæ-Senecionideæ).

G. foliis, inermibus, erecto-patentibus, pinnatisectis, subcarnosis.

Herba perennis, diffusa, undique glabra 30 cm. alta; rami late patentes incurvique, foliosi, sæpius 5–7 cm. longi; folia subopposita, erecto-patentia, dense imbricata, linearia, integra vel sæpissime sursum pinnatifida, lobis utrinque 3–4, linearibus, acutis, subcarnosa, semi-amplexicaulia, 1–1·5 cm. longa, 0·2–0·3 cm. lata, lobis 0·15 cm. longis; pedunculi axillares late patentes, incurvi, filiformes, levissimi, purpurei, 8–10 cm. longi; capitula crateriformia, 0·6 cm. longa, 1 cm. lata; involucri squamæ 13–14, acuminatæ, purpureæ, tubum æquantes; flores radii circa 13, ligulis 0·5 cm. longis; achænia clavata, 10 costata, rugulosa.

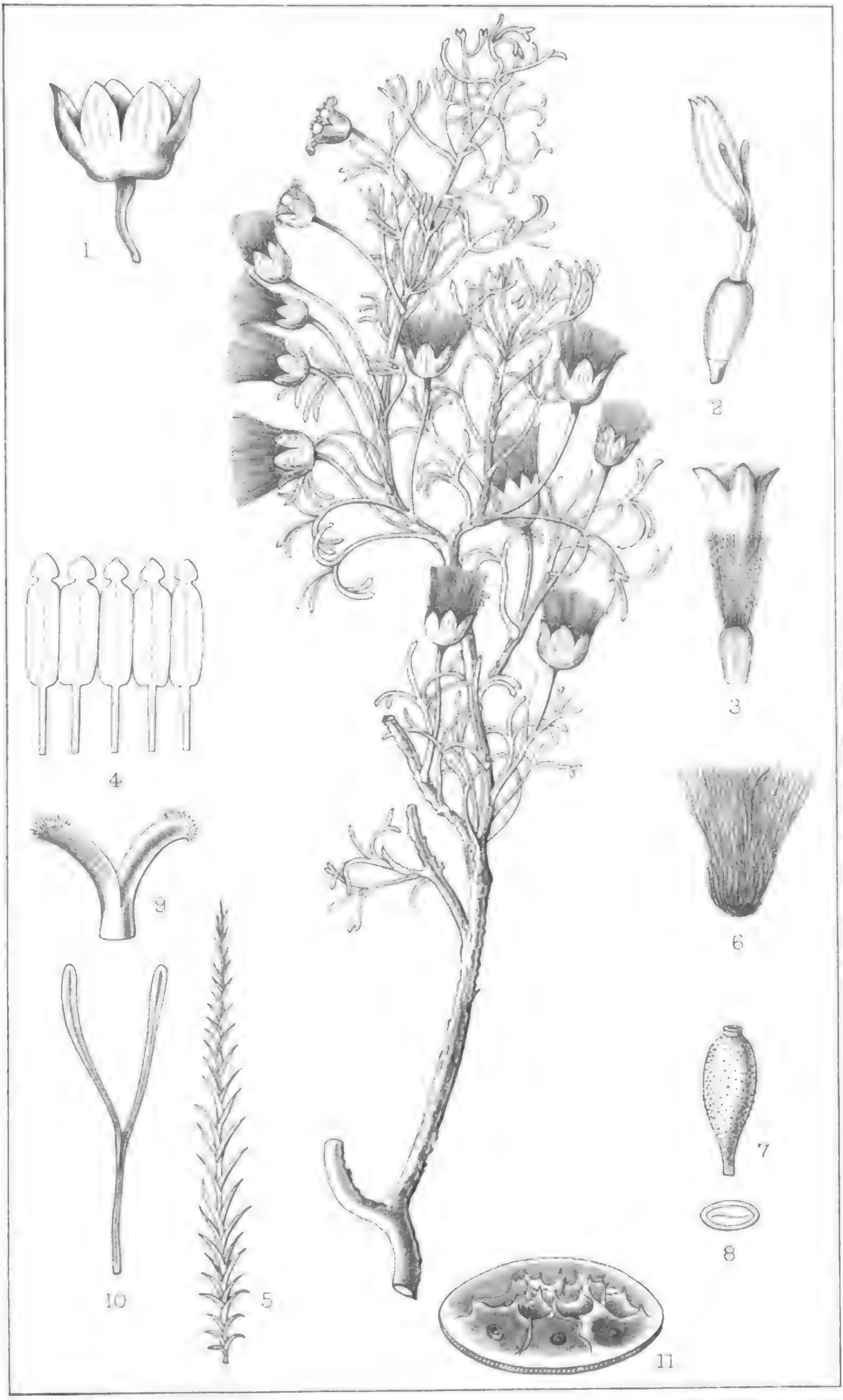
HAB.: Cape Colony; Prince Albert Division; in stony places, on the summit of the Zwartebergen, near Zwartberg Pass, approx. alt. 1,725 meters, Dec., *H. Bolus*, 11561.

Intermediate between *G. trifurcata* and *G. munita*, differing from the former by its pinnatisect leaves, and the short ligules of its ray flowers; and from the latter by its erect-spreading, unarmed, fleshy, and nerveless leaves.

OSTEOSPERMUM ELEGANS, Bolus, n. sp. (Compositæ-Calendulaceæ).

O. ilicifolio affine, sed foliis irregulariter pinnatifidis, marginibus planis; achæniis ellipticis, acute triangularibus, distinctum.

Fruticulus undique plus minusve viscoso-puberulus; rami adscendentes, foliosi, internodiis 0·5–1 cm. longis; folia alterna, sessilia, patentia reflexave, circumscriptione oblonga vel lanceolata, acuminata, irregulariter pinnatifida, semi-amplexicaulia, nervo medio utrinque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H. Bolus del

West, Newman lith

LASIOCOMA PETROPHILOIDES *(DC) Bolus.*

prominente, 3–8 cm. longa, 1–3 cm. lata, segmentis lanceolatis, acutis mucronulatis 0·4–1·4 cm. longis, interdum dentibus 1–2 instructis; capitula solitaria, vel rarius in corymbo laxo, foliato terminali, 2–5 capitato disposita, campanulata, 0·8 cm. longa et lata; involucri squamæ sub 2-seriatæ, oblongæ, acuminatæ cuspidatæ, margine membranaceæ ciliolatæ, intimis flores disci excedentibus; flores radii circa 10, ligulis 1·2 cm. longis, 0·4 cm. latis; achænia elliptica, acute 3-angulata, longitudinaliter 1-nervia, levia.

HAB.: Cape Colony; hills near Clanwilliam, approx. alt. 150 meters, Oct., *H. Bolus* 9043 (in herb. Kew and my own).

A pretty shrub characterised by its pinnatifid elegantly recurved leaves with rather distant lobes, and its broad and pale involucral scales.

URSINIA SUBINTEGRIFOLIA, Bolus, n. sp. (Compositæ-Arctotideæ. § Eu-Ursinia).

U. foliis sæpius integris, subtus squamellis minutis appressis indutis; radii ligulis discoloribus; achæniis glabris pappo sæpe deficiente.

Fruticulus humilis, 12–22 cm. altus; rami decumbentes vel adscendentes, foliosi, 4–7 cm. longi; folia linearia vel oblanceolata e basi angusta sursum ampliata, acuta, sæpius integra, rarius apicem versus pinnatifida vel irregulariter 2–3-fida, coriacea, rigida, interdum involuta, superne glabra, inferne squamellis minutis, appressis, sparsis, induta, 3–6 cm. longa, lobis exemptis, 0·2–0·3 cm. lata, lobis linearibus, acutis, 0·3–0·4 cm. longis; pedunculi solitarii, terminales, parce squamellati, 9–17 cm. longi; capitula crateriformia, 1 cm. longa, 1–1·2 cm. lata; involucri squamæ 4-seriatæ, lanceolatæ, acutæ, exterioribus omnino herbaceis, interioribus apicibus amplis, membranaceis, 0·2–0·8 cm. longæ; receptaculi paleæ oblongæ, apice dilatatæ, laceratæ; flores radii 10–14, ligulis discoloribus, 0·7 cm. longis; ovaria omnino glabra pappo sæpe deficiente, dum adsit, extimo e squamis suborbicularibus, erosulatis, aliis subopacis, aliis subhyalinis, intimo e setis capillaceis.

HAB.: Orange River Colony; mountains, Bester's Vallei, near Witzies Hoek, approx. alt. 1,650–2,000 meters, Dec., *H. Bolus*, 8206 (in herb. Kew).

URSINIA ERECTIFOLIA, Bolus, n. sp. (§ Sphenogyne).

U foliis 2–3-furcatis, pinnatisectisve, squamis involucri omnibus apice membranaceis, ligulis florum radii discoloribus.

Lignosus, erectus, foliosus, parce minuteque albo-tomentulosus, 7–12 cm. longus; folia imbricata erecta, rarius linearia indivisa, vel sæpius supra medium bi-trifurcata, vel pinnatisecta, marginibus inflexis, segmentis utrinque 1–2, linearibus acutis 0·5–1 cm. longis, 1-nervia, tomento deciduo puberula, minute impresso-punctulata, 3–3·5 cm. longa, 0·2 cm. lata; pedunculi terminales, tomentulosi, 2–3 cm. longi; capitula crateriformia, 1 cm. longa, 1·5 cm. lata; involucri squamæ 4-seriatæ, lanceolatæ, omnibus apice membranaceis pubescentibus, 0·2–0·7 longis; receptaculi paleæ cuneatæ vel flabelliformes, hyalinæ, laceratæ; flores radii ad 17, ligulis 0·8 cm. longis, subtus discoloribus; ovaria glabra; pappus 1-seriatus, squamis suborbicularibus; achænia haud suppetunt.

HAB.: Transvaal Colony, on the "High Veld," in grassy places near Belfast, approx. alt. 2,000 meters, Dec., *Bolus*, 12056.

In general appearance resembling *U. annua, Less.*, but the leaves are less divided, the involucral scales all membrane-tipped, the rays discoloured beneath, and the scales of the pappus in a single series.

TRIPTERIS KARROOICA, Bolus, n. sp. (Compositæ-Calendulaceæ, § Fruticosa).

Ad T. spinescentem accedit, sed ramulis inermibus, foliis linearibus differt.

Fruticulus undique plus minusve visciduloso-scaberulus, 15–20 cm. altus; rami adscendentes, rigidi, striati, pallidi, in pedunculos monocephalos, bracteatos, 3–8 cm. longos abeuntes, internodiis 0·5–1·5 cm. longis; folia alterna, sæpius erecta, sessilia, linearia, acuta, mucronata, ciliolata, basi angustata, sæpe complicata, inflexave, lana alba in axillis vestita, nervo medio inferne prominente, 1·5–2·5 cm. longa, 0·2 cm, lata; capitula campanulata, 0·8 cm. longa, 1 cm. lata; involucri squamæ 2-seriatæ, lanceolatæ, acuminatæ, marginibus anguste membranaceis, intimis quam flores disci brevioribus; flores radii circa 12, aurantiaci, ligulis 0·9 cm. longis, 0·3 cm. latis; achænia 0·6–0·7 cm. longa, alis membranaceis 0·2 cm. latis ornata, inter alas transverse rugosa.

HAB.: Cape Colony; on stony hills near Prince Albert, approx. alt. 700 meters, Dec., *H. Bolus*, 11528 (in herb. Kew, my own, &c.).

TRIPTERIS CONFUSA, Bolus, n. sp. (§ Paniculatæ).

Ad T. arborescentem accedit, sed foliis majoribus inferioribus petiolatis, achæniis minoribus, alis multo angustioribus, differt.

Herba annua, undique plus minusve glanduloso-pubescens, 30–50 cm. alta; caulis erectus, striatus, internodiis 1–2 cm. longis; folia alterna, erecto-patentia, inferiora petiolata, petiolo semi-amplexicaule, 1·5–2 cm. longo, lanceolato-ovata, acuta, serrato-dentata, puberula, nervis primariis tribus, adscendentibus, 5–6·5 cm. longa, 2·5–3 cm. lata, folia superiora amplexicaulia, sæpe basi auriculata, acuminata, integra, 1–3 cm. longa; capitula crateriformia, 0·8 cm. longa, 1 cm. lata, in corymbo laxo, 6–9 cephalo, bracteolato, disposita; involucri squamæ 1-seriatæ, lanceolatæ, cuspidatæ, marginibus membranaceis 0·6–0·8 cm. longæ; flores radii 15–17, ligulis 2 cm. longis; achænia florum radii dorso rugosa, 0·4 cm. longa, alis 0·1–0·15 cm. latis, disci? (monstrosa?) teretia, exalata, 0·8 cm. longa.

HAB.: Little Nama'land; between Port Nolloth and Oograbies, approx. alt. 90 meters, Aug., *Bolus*, 9607; near Spektakel, approx. alt. 460 meters, Sept., *Bolus*, 9608.

The achenes in our specimens have fallen from the heads, and we are unable to determine whether the terete exalate form belongs to the disk or the ray flowers, although most probably to the former. In either case they might be a monstrous form.

GAZANIA LINEARIFOLIA, Bolus, n. sp. (Compositæ-Arctotideæ).

G. foliis caulinis, radicalibusque linearibus, setuloso-ciliatis; involucri squamis quam tubus duplo longioribus.

Ad G. armerioidem accedit.

Herba perennis, 20–25 cm. alta; rhizoma reliquiis fibrosis foliorum delapsorum interdum coronatum; folia pleraque radicalia, adscendentia, rigida, e basi dilatata linearia, acuta, setaceo-mucronata, marginibus revolutis, distanter setuloso-ciliatis, subtus nervis 3–5, prominentibus, 5–8 cm. longa, 0·1–0·2 cm. lata, caulina distantia sensim minora in calyculum abeuntia; caulis simplex, erectus, tomentosus; capitulum solitarium, cyathiforme, basi rotundatum, 2·5 cm. longum, 2 cm. latum; involucri squamæ 2–3-seriatæ, lineares, acuminatæ, intimis setaceis, corollæ ligulas æquantibus, exterioribus scabridis rigide ciliatis, duplo longiores quam tubus, bracteolis squamis conformibus vestitus; flores flavi, radii ligulæ ca. 17, subtus discolores; achænia dense sericeo-villosa, pappi squamis biseriatis, lanceolatis, setaceo-acuminatis.

HAB.: Transvaal; grassy places, near Belfast, approx. alt. 1,700–1,850 meters, Dec., *H. Bolus*, 12067.

This approaches to the genus Berkheyopsis O. Hoffmann, and perhaps would be regarded as such by some writers. But I have been unable to find any valid characters by which to separate it from Gazania.

BERKHEYA MILLERIANA, Bolus, n. sp. (Compositæ-Arctotideæ. § Stobæa).

Ad B. seminiveam Harv. et Sond. proxime accedit, sed foliis majoribus, nervis obscuris, capitulo subsessili, squamis involucri distanter ciliatis, subtus albo-tomentosis distinguitur.

Herba annua, erecta, 80 cm. alta; caulis simplex, tota longitudine foliatus, striatus, puberulus, brunneo-purpureus, internodiis 2·5–3·5 cm. longis; folia alterna, semi-amplexicaulia, inferiora lanceolato-ovata, basi angustata, acuta, intermedia lanceolata, superiora anguste lanceolata, crenulata, spinoso-ciliata, superne glabrescentia nisi spinis paucis hinc inde prope marginem armata, inferne albo-tomentosa, nervis obscuris, primariis utrinque 5–6, patentibus, 5–9 cm. longa, 1·5–4 cm. lata; capitulum solitarium, crateriforme, radiatum, 4 cm. longum, 7 cm. latum; involucri squamæ lineares, acuminatæ, rigide et distanter spinoso-ciliatæ, mucronatæ, superne puberulæ, inferne albo-tomentosæ, intimis ligulas æquantibus, quam tubus circa duplo longiores; achænia villosa, pappi squamis oblanceolatis, obtusis, 0·2 cm. longis.

HAB.: Swazieland; "High Veld," 'Mbabane, near Dalriach, in grassy places, approx. alt. 1,410 meters, Dec., *H. Bolus*, 12078.

Named in honour of Allister Miller, Esq., of Dalriach, who takes a keen interest in the Flora of Swazieland, and who afforded me the most generous assistance on my collecting tour.

BERKHEYA FRANCISCI, Bolus, n. sp. (Compositæ-Arctotideæ. § Euopis).

B. caule albo-araneoso; foliis superne cinereo-araneosis, inferne dense albo-tomentosis. B. buphthalmoidei (DC.) Schltr. affinis.

Herba annua, valida, erecta, undique, floribus spinisque exceptis, plus minusve dense albo-tomentosa, 50–90 cm., alta; caulis simplex, basi dense foliosus, internodiis superioribus 4–6 cm. longis; folia inferiora oblonga, pinnatifida, acuta, lobis semiorbicularibus, sinuatis, 15–20 cm. longa, 4–7 cm. lata, superiora sensim minora paucioraque 3–8 cm. longa, 1–3 cm. lata, omnia rigide spinoso-ciliata; pedunculi ex axillis foliorum caulinorum erecto-patentes, apicem versus magis aggregati, 3–4 cm. longi; capitula crateriformia, 3 cm. longa, 3 cm. lata; involucri squamæ 4-seriatæ, lanceolatæ, acuminatissimæ, in spinas rigidas, pungentes desinentes, margine spinoso-ciliato, intimis flores radii excedentibus; radii flores 20–30, disci numerosi; achænia dense villosa, pappi squamis lanceolatis, laceratis.

HAB.: Cape Colony; district Oudtshoorn, in a rocky valley on the

summit of the Zwarteberg Pass, approx. alt., 1,480 meters, Dec., *Frank Bolus.* No. 12082 of my herb. (in herb. Kew, Berlin, &c.).

A fine species, sometimes reaching to a height of 3 or 3½ ft. Most nearly allied to *B. buphthalmoides* (DC.), *Schltr.*, Journ. Bot., 1897, p. 343, differing by its more deeply cut leaves, which are covered with a closer white felted wool on the under surface, and by its narrower involucral scales.

ERICA RECTA, Bolus, n. sp. (§Pyronium).

E. unilaterali Klotzsch affinis, floribus majoribus, aristis antherarum liberis, ovario glabro differt.

Rami erecti, stricti, approximati, pallide cinerei, fere glabri, 18–20 cm. longi vel ultra; ramuli semper terni, internodiis 0·6–3·3 cm. longis, primum breviter patentes deinde stricte adscendentes, simplices vel iterum et similariter ramosi, dense foliosi usque ad apicem, puberuli, 1·2–7·5 cm. longi; folia 3-na erecta dense imbricata, juniora duplo longiora, vetustiora ¼ vel ⅓ longiora quam internodia, brevissime petiolata, oblonga vel late linearia, subobtusa glabra, subtus sulcata, marginibus nudis leviter inflexis, 0·2–0·35 cm. longa; flores terminales normale 3-na, interdum bini vel solitarii, patentes vel deflexi, rosei, corollæ limbo discolore; pedicelli albo-tomentosi rosei, 0·2–0·3 cm. longi; bracteæ omnes arcte approximatæ, leviter patentes, lanceolatæ, infra scariosæ, apice callo foliaceo coloratove desinentes ± 0·2 cm. longæ; sepala bracteis conformia sed latiora et subinæqualia, lanceolata ovatave, apice calloso magis distincter canaliculato, sæpius rosea, 0·25 cm. longa; corolla ovato-urceolata, fauce leviter constricto, ore latiusculo, glabra, 0·5–0·55 cm. longa, limbi segmenta patentia, semi-orbicularia, minute ciliolata, ± ¼ longitudinis tubæ; antheræ semi-exsertæ (demum fortasse exsertæ), laterales, a latere visæ longitudinaliter anguste semi-ovatæ, leves, 0·15 cm. longæ, basi aristatæ, aristis liberis stricte deflexis, longitudine dimidio antheræ; stylus exsertus; stigma capitatum; ovarium globosum, glabrum, ovulis numerosissimis minutis.

HAB.: Cape Colony; Coast Region; district Ladismith, on the Little Zwartberg range, near Vaartwel and the Gamka River, approx. alt. 900 meters, fl. June, *Dr. R. Marloth*, 3993! (in herb. Kew, my own, &c.).

Structurally near to *E. lateralis Klotzsch*, but with larger flowers, free anther-awns, and a glabrous ovary. The remarkably straight ternate branches and very regular erect leaves, would, if they should prove constant, distinctly characterise this species. But the material at our disposal is scanty.

PHYLLOPODIUM LINEARIFOLIUM, Bolus, n. sp. (Scrophulariaceæ).

P. habitu fruticuloso, foliis linearibus.

Suffrutex exsiccatione haud nigricans, 20 cm. altus; rami fastigiati, pubescentia in lineis longitudinaliter disposita vestiti; folia sessilia axillis sæpe gemmiferis, linearia, acuta, subcarnosa, glabra, sensim in bracteas abeuntia, 1–2·5 cm. longa, 0·1–0·15 cm. lata; spicæ nunc sphericæ nunc ovatæ, 1–1·5 cm. longæ, 1·4–1·5 cm. latæ; bracteæ lanceolatæ, acuminatæ, longe ciliatæ 0·5 cm. longæ; calyx subæqualiter 5-fidus, tubo 0·1 cm. longo, segmentis lanceolatis, acuminatis longe ciliatis, 0·3 cm. longis; corolla 0·6 cm. longa, ore parce barbata, flava, lobis oblongis, obtusis, 0·1–0·2 cm. longis; antheræ manifestæ; stylus puberulus corollam æquans; ovarium glabrum.

HAB.: Cape Colony; at the foot of the northern slopes of the Zwartebergen, near Prince Albert, approx. alt. 850 meters, Dec., *H. Bolus*, 12189 (in herb. Kew, Brit. Mus., Berlin, &c.).

HARPAGOPHYTUM PEGLERÆ, Stapf. (Pedaliaceæ).

H. procumbenti DC. affinis sed fructu ad margines cresta duplica spinoso-lobata instructo differt.

Herba procumbens aspera vel novellis exceptis subglabra, undique glandulis mucilaginiferis aspersa; folia elliptica repanda vel pinnatilobata, lobis grosse repando-dentatis, obtusa basi breviter subcuneata, 4–7 cm. longa, 3–4·5 cm. lata; petiolus 1–2 cm. longus; flores solitarii vel in cymis axillaribus sessilibus 2- raro 3-floris; pedicelli sub anthesi 0·5–0·8 cm. longi; calyx ad 0·9 cm. longus, asperulus, segmentis e basi lanceolata subulatis; corolla 4–6 cm. longa, tubus inferne ad 1 cm. anguste cylindricus, abhinc dilatatus, ore 1 cm. diametro, pallidus vel purpureo suffusus; limbus 3 cm. diam., purpureus vel albidus, lobis suborbicularibus; capsula ambitu elliptica, 4·5 cm. longa, 3 cm. lata; prominenter nervosa, cresta duplica indurata lobata, lobis spinoso-dentatis circumdata, dorso et facie spinis binis brevibus conicis validis rigidissimis instructis.

HAB.: Transvaal Colony; in sandy loam near Rustenburg, *Miss Alice Pegler*, 1027! Waterberg district, near Warm Bath, in the "Bosch Veld," approx. alt. 1,100 meters, Jan., *Bolus*, 12199! (in herb. Kew, Bolus, &c.).

SELAGO SWAZIENSIS, *Rolfe*, n. sp. (Selaginaceæ).

Fruticulus nanus, diffusus; caules teretes, pubescentes, ramosi; folia brevissime petiolata, late elliptica, subobtusa, sæpissime plus minusve crenata, pubescentia, 0·5–1·5 cm. longa, 0·2–0·8 cm. lata; flores subsessiles, capitulata, capitulis numerosis in paniculas laxas subcorymbosas dispositis; bracteæ lineari-oblongæ, obtusæ, subincurvæ, ciliatæ, 0·3–0·4 cm. longæ; calyx campanulatus, 0·4 cm. longus, puberulus, breviter quinquelobus, lobis deltoideo-oblongis, obtusis, 0·2 cm. longis; corollæ tubus oblongus, 0·8 cm. longus, lobis oblongis, subæqualibus, 0·15–0·2 cm. longis.

HAB.: Swazieland; grassy hills near Dalriach, 'Mbabane, approx. alt. 1,450 meters, Dec., *H. Bolus*, 12226! "Flores albi." (In herb. Kew, Brit. Mus., Berlin, &c.).

Allied to *S. Muddii Rolfe*, but having rather larger, less numerous leaves, heads more disposed in lax panicles, and in the details of the flowers. The plant shows a tendency to turn black in drying, in this respect resembling *S. monticola Wood & Evans*, which is a much taller, less decumbent plant.

PROTEA CHIONANTHA, *Bolus*, n. sp. (Proteaceæ-Proteeæ). § I. Acrocephalæ. 2. Subacaules).

P. Scolopendrium valde affinis sed omnibus partibus multo majoribus et squamis involucri undique dense griseo-tomentosis differt.

Caulis abbreviatus; folia sparsa, erecta, oblanceolata, acutiuscula, longe petiolata, marginibus involutis, rigidissima, coriacea, prominenter venosa, glaberrima, 34 cm. longa, 4–5 cm. lata, petiolis 13 cm. longis; capitulum sessile, erectum, circa 15 cm. longum, 14 cm. latum; involucri squamæ pluri-seriatæ, imbricatæ, lanceolatæ, longe acuminatæ, denso tomento griseo undique tectæ, 5–10 cm. longæ; calyx 8 cm. longus, tubo extus glabro, intus marginibus tantum linea albo-tomentosa bene definita ornato, segmentis dense barbatis; ovarium dense albo-pilosum, 1·2 cm. longum; stylus basi lateraliter compressus, 6·7 cm. longus; stigma filiforme, sulcatum, glabrum, 0·7 cm. longum.

HAB.: Cape Colony; Clanwilliam Div., summit of Sneeuwkop, in rocky places, approx. alt. 1,940 meters, *A. A. Bodkin*, No. 8675 of herb. Bolus (in herb. Kew).

I am informed by Mr. C. L. Leipoldt, who knows the locality well, that this species occurs not infrequently on the Sneeuwkop, where it is called the "Sneeuw-bloem," either from its general white appearance or from the fact of the snow often lying for some time on the broad-topped heads.

GNIDIA FRANCISCI, Bolus, n. sp. (Thymelæaceæ-Eugnidia. § Involucratæ (Gilg).

G. floribus 4-meris, capitulis involucratis 5-floris, petalis bipartitis majusculis.

Fruticulus humilis a basi parce ramosus, ad 20 cm. alt.; rami vel simplices vel semel terve divisi, subtetragoni, graciles, glabri vel apices versus pilosi; folia opposita erecta imbricata subulata acuminatissima gracilia, marginibus incurvis, dorso rotundata, junioribus pilosis apice barbatis demum glabrescentibus, 0·9–1·3 cm. longa, 0·06–0·1 cm. lata; flores 4-meri sæpius (an semper?) in capitulis 5-fl., solitariis, vel capitulis in glomerulis 2–3 aggregatis; bracteæ involucrantes 5, e basi lata lanceolatæ acuminatissimæ parce pilosæ substriatæ, pallidæ, 0·35–0·4 cm. longæ; receptaculum tubulosum apice parum ampliatum, 1–1·3, vel, post anthesin, usque ad 1·7 cm. longum; sepala ovata vel oblonga 0·4 cm. longa, extus sericeo-villosa, intus subglabra; petala bipartita, segmentis oblongis circ. 0·15 cm. longis; fructus ovatus sericeo-villosus subsessilis, 0·4 cm. longus.

HAB.: Cape Colony, Oudtshoorn district, on the summit of the Zwartbergen, near the Pass, approx. alt. 1,725 meters, in rocky places, Dec., *Frank Bolus* (No. 11631 of herb. Bolus) (in herb. Kew, &c.).

The habit resembles that of *G. linoides*, Wikstr., but is otherwise very different; the flowers are cream-coloured.

ON ROCK-ENGRAVINGS OF ANIMALS AND THE HUMAN FIGURE, THE WORK OF SOUTH AFRICAN ABORIGINES, AND THEIR RELATION TO SIMILAR ONES FOUND IN NORTHERN AFRICA.

By L. Péringuey.

Plates XII., XIII., XIV.

(Read May 30, 1906.)

Figures engraved on hard rocks have been known in South Africa for some time. They are far from uncommon, along the banks of the Vaal River from Vereeniging in the Transvaal, where they have been quite lately discovered, to its junction with the Orange River, and also along that river; they have been found in the Klerksdorp District, in the Transvaal, have been reported from Kuruman, and are known to occur in the vicinity of Vryburg. They are found in the Victoria West and Britstown Districts of the Cape Colony, in Prieska, Clanwilliam, and Beaufort West; are said to occur in the Middleburg District, Cape Colony, in the Kalahari, and lately they have been discovered in Humansdorp. A systematic search for these interesting relics will probably lead to their discovery in many other parts of the Cape Colony and elsewhere in South Africa. I am not aware of any of them having been met with north of the localities mentioned, and the rock carvings found in Southern Rhodesia are pronounced to be altogether different from those which form the subject of this paper.

But it is not in South Africa only that these "rock-engravings," or "graffiti," or "rupestres" are found.

Barth, during his journey in Africa, discovered rock-engravings which, from his description, as well as from the vignette he gives, are of a workmanship very similar to, if not identical with, those met with in South Africa. On two occasions he mentions this discovery in his "Travels in Africa," London, 1857 (vol. i., chap. xii., p. 293):

"Notwithstanding our perilous situation, I could not help straying about, and found on the blocks over the tebki, or pond, some coarse rock-sculptures representing oxen, asses, and a very tall animal which, according to the Kéb-owi, was intended to represent the giraffe." Barth was then to the north-west of Lake Chad.

(Ibid., chap. ix., p. 196, cum fig.): "Scarcely had we pitched our tents, when we became aware that the valley contained some remarkable sculptures deserving our particular attention. The spot where we had pitched our tents afforded a very favourable locality for commemorating any interesting events; and the sandstone blocks which studded it were covered with drawings representing various subjects, more or less in a state of preservation. With no pretensions to be regarded as finished sculptures, they are made with a firm and steady hand, well accustomed to such work, and, being cut to a great depth, bore a totally different character from what is generally met with in these tracts. The most interesting sculpture represented the following subject, the description of which I am, unfortunately, able at present to accompany with only an imperfect woodcut, &c." (Fig. 12).

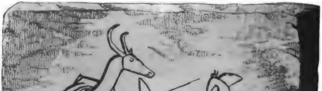

FIG. 12.

"The sculpture represents a group of three individuals of the following character and arrangements. To the left is seen a tall human figure, with the head of a peculiar kind of bull, with long horns turned forward and broken at the point; instead of the right arm he has a peculiar organ terminating like an oar, while in the left hand he carries an arrow and a bow—at least such is the appearance—though it might be mistaken for a shield; between his legs a long tail is seen hanging down from his slender body. The posture of this figure is bent forward, and all its movements are well represented. Opposite to this curious individual is another one of no less remarkable character, but of smaller proportions, entirely human as far up as the shoulders, while the head is that of an animal which reminds us of the Egyptian ibis without being identical with it. The small pointed head is furnished with three ears, or with a pair of ears and some other excrescence, and beyond with a sort of hood, &c.; over the fore part of the head is a round line representing some ornament, or perhaps the basilisc. This figure likewise has a bow in its right hand, but, as it would seem, no arrow, while the left hand is turned away from the body. Between these two half-human figures, which are in a hostile attitude, is a bullock, small in proportion to the adjacent lineaments of the human figure, but chiselled with the same care and the same skilful hand, with the only exception that the feet are omitted, the legs terminating in points—a defect which I shall have occasion to notice also in another sculpture. There is another peculiarity about this figure—the upper part of the bull, by some accident, having been hollowed out, while in general all the inner part between the deeply-chiselled outlines of these sculptures is left in high relief. The animal is turned with its back towards the figure on the right, whose bow it seems about to break. The block on which it was sculptured was about four feet in breadth and three in height. It was lying loose on the top of the cliff."

Barth, of course, proceeds to attribute to these sculptures an Egyptian origin, but those acquainted with Bushman paintings and the mythical subjects often represented by them, will see there the delineation of a myth, one of the actors being the Ibex; the other personage may be perhaps "Heitsi-Eibit," the one-legged man, a famous person in the mythology of the Khoi Khoin. This suggestion is not so hazardous as it might at first appear. I give (Fig. 13) a reproduction by a Bushman artist of two mythological personages having a confabulation. The head and neck, which are painted white, are those of the South African Rheebok, or perhaps of the Duiker antelope; the rest of the body is human and painted red. In Barth's vignette the head is what is known to the Egyptologists under the name of "Ibex," and is similar to that occurring on pottery and other remains of the pre-dynastic Egyptian race.*

Of course it is not an *Ibex*, because the horns of that wild goat sweep backwards, but it might be the representation of the *Dorcas* or the Seemering gazelle, the horns of which are somewhat long and slender and their tips turned inwards and forwards.

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* Cf. earthenware box of the Predynastic Period figured in "Budge's Egypt in the Neolithic and Archaic Period," vol. i., 1902, p. 98, Lond.

Owing to the gradual penetration of the French into the Sudan, there has been brought lately to light the presence of "rock-engravings" in the southern part of Algeria, and especially in the "In Salah" region, some 1,100 miles as the crow flies from the northern part of the Lake Chad, and somewhat in the direction of the locality mentioned by Barth, but also further south. The Arabic name is there, "the written stones."

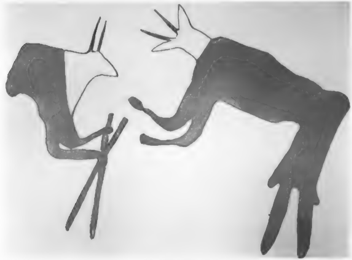

FIG. 13.

A careful examination of these engravings has shown that they are of two kinds.

Not only the technique differs, but also the reproduced figures, and the patination is different according to *M.* G. B. Flamand, of the Geological Survey of Algeria, who discovered and investigated those relics.* In several places he was able to find representations of *Bubalus antiquus*, an extinct species of Buffalo, whose surviving ally is the "Arni" or Indian Buffalo. Distinguishing between these engravings and others attributed to a Lybico-Berber race, *M.* Flamand says, "Prehistoric man possessed a sense of drawing, and although he never took perspective into account, he has produced faithful representations which are not without a good deal of spirit. The representations are *line drawings*, the depth of the lines varying from 5 to 12 mm., and they have a thick patination. The Lybico-Berber is not such a good artist, and its work consists of *pointing* (pointillage); figures of that period are much less darkly patinated, and it is quite easy to distinguish the former from the latter. Moreover, this pointing covers, in several places, the prehistoric engravings which represent a fauna no longer existing in the country; the elephant, the rhinoceros, the buffalo have disappeared. In the Lybico-Berber engravings the reproductions are that of alphabetical signs, or of animals still living in the region," &c.

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* "L'Anthropologie," vol. ii., p. 555. 1900. Paris.

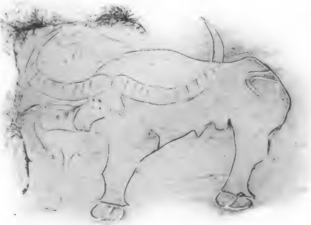

FIG. 14.

In the figure given by Pomel in his paper on *Bubalus antiquus*, Duv.,[*] and here reproduced, it is easy to recognise in the background the *Rhinoceros simus*, from the manner it carries its head. Pomel, who did not know the animal, mistakes it for the wart-hog, *Phacochœrus æthiopicus*. Flamand is therefore justified in concluding that it is impossible to admit that an artist might have depicted by pure chance, and in several places, an animal which no longer existed at the time he made a figure of it—figures the authenticity of which are corroborated by a study of the reconstructed skeleton.[†] Thus at very remote time (recent quarternary) there were in Algeria artists sufficiently observant and skilled to represent faithfully the animals they then saw, by using stone implements as tools, just as in the grottoes of Aquitaine, prehistoric man engraved on bones, or other material, figures of the reindeer, the aurochs, the bear or the mammoth, so proving his contemporaneity with these animals.

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[*] "Carte Geologique de l'Algerie Bubalus Antiquus," by A. Pomel. Alger, 1893.

[†] Pomel, *loc. cit.*, p. 81 *et sequit*. The figure is almost of the size of the animal, viz., 1m. 71c. at the shoulder, 1m. 53c. at the hindquarters. The restoration of the animal gives 1m. 85c. and 1m. 70c. respectively as the height of these parts.

I may add that the remains of a buffalo of gigantic size, allied to, but differing by the shape of the horns, from the Northern African Buffalo, *i.e.*, *Bubalus baini*, have been discovered in South Africa;[*] and that I found with its remains stone implements which I believe, however, to be of a posterior date.

Foureau, in his exploration of the Sahara, has met in what he calls Zone X, in the mountains and plateaux of the Northern Touaregs, rock-engravings comparable to those first mentioned by Barth,[†] and these he describes as follows (p. 1087):—

". . . smooth walls of granite of great height; these vertical rocks are covered with designs (dessins) of all kinds: men, giraffes, antelopes, (?)[‡] horses, ostriches, bustards, guinea-fowls. These representations have been obtained by means of numerous punchings, not simple lines, but lines formed by a sort of closely-set pointing produced by numerous blows, and giving to the line a certain width. These engravings are covered by numerous inscriptions in Tifinagh and Arabic characters, crossing in all directions; the line of the latter is finer, and the workmanship is different. . . . On the banks of the Ouad Tidek, rise numerous rounded hillocks (mamelons), natural, not artificial, and consisting of large blocks of gneiss or granite with more or less flat surfaces. Most of these blocks are covered with rock-engravings (sculptures rupestres) representing men with large phalli, antelopes with or without horns, giraffes, ostriches, guinea-fowls, &c. In those, as in the ones above mentioned, the outline is produced by a sort of pointing, and they have likewise numerous inscriptions in Tifinagh or Arabic characters engraved across them."

In one spot, however, the traveller found the representation of an antelope, 73 cm. long by 51 cm. high, engraved in simple line, and he adds: "Further south (than the mountains where live the northern Touaregs) I did not meet with any inscriptions, but I know that in the mountainous parts of the Aïr one comes across a fair number of these rock-engravings."

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[*] Orange River Colony, Basutoland; Darling, Cape Colony.

[†] "Documents scientifiques de la Mission Saharienne," par F. Foureau. Paris, 1905.

[‡] The query is mine.

If we turn to the South African engraved stones we notice that the workmanship differs from that of the prehistoric "rupestres" of Northern Africa. All those that I have examined or of which I have seen photographs, are made by pointing or punching, not by line drawing, except one which pertains to both these processes. The technique is thus similar to that of the Touareg country.*

The depth of this pointing is variable.

In the figs. of Plate XII., the punching is deep and uneven, the surface is a shaley quartzite, naturally well polished.

Fig. 1 is a very good delineation, on the same kind of rock, of the Koodoo (*Strepciceros kudu*).

Fig. 2 is that of an undetermined, somewhat unreal antelope, possibly meant to represent the Blue Wildebeest (*Connochaetes taurinus*).

These two figures come from the Klerksdorp District in the Transvaal, and are probably the work of the same artist.

Fig. 3 is a giraffe, no longer drawn in outline only; the body is also pointed or etched; towards the edge of the slab is seen the head of another giraffe.

Fig. 4 is an ostrich; the reproduction is excellent; there also the body is etched, and the attitude is perfect.

Mr. C. J. Swierstra, of the Pretoria Museum, has sent me excellent photographs of work of the same technique and also found in Klerksdorp. They represent either the Guinea-fowl, or, more probably, the large bustard or Gom Paw (*Otis kori*), the Cape Ant-eater (*Orycteropus capensis*), the Gemsbok, the Eland, &c.

These engravings with deep, broad, intaglio pointings might be very ancient or not. The surface of the rock and the lines of the animals do not show much trace of weathering. But the same cannot be said of the engravings found along the banks of the Orange River or of the Vaal River. There the rock chosen is the smooth surface of boulder-like masses of weathered dolerite, or diabase.

Fig. 5 of Plate XIII. is incomprehensible. It is impossible to say if hieroglyphs are meant, or if it is merely the expression of a whimsical fancy on the part of the engraver. The lines, for they are lines rather than pointings, are the deepest I have yet seen.

Fig. 6 represents a Gemsbok (*Oryx gazella*) checking itself while at full speed before the extraordinary object set before it; at an angle of the face of the rock is a similar figure which, not having been chalked, does not appear in the figure. Is it intended to alarm the game and drive it into another direction? I am informed by Mr. C. E. Stewart that he has seen many similar figures that look like pegged-out skins near Kuruman on rocks forming the bottom of a "pan."

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* Line drawings have, however, been discovered quite lately of a far superior type, and will be the subject of another note.

Fig. 7 is that of an Ostrich seemingly rising.

Fig. 8 is that of the Wildebeest. Judging from the shape of the horns it is not the Black Wildebeest (*Connochaetes gnu*), which is there represented, but its ally, the Brindled Gnu (*Connochaetes taurinus*), which is found now further north only. The attitude of the animal, which is so remarkable owing to the great sloping of the hindquarters, is admirably reproduced.

On other stones are depicted, among others, a two-horned rhinoceros and an equine animal, probably a zebra, &c. The original rock-engravings are in the South African Museum. The hollowed parts have been very carefully touched with chalk to bring them out clearly enough to be photographed, because the figures engraved on the dolerite rock are not deep; many seem to have weathered away at the same ratio as the surface of the rock itself; in many the patina is almost that of the untouched rock surface, or the outline and etched parts are worn out nearly flush with the original plane of the rock. Most of them would be passed unnoticed even by people in search of them, except when dew or rain has been retained in the very shallow cavities. Personally I think that some specimens of this type of rock engravings are extremely ancient.

Figs. 9 and 10 of Plate XIV. are a good representation of such engraved stones photographed *in situ*. They were kindly sent me by Mr. F. B. Parkinson, who writes: "One of the stones is within a few yards of the other, and the engraving is not apparently so old, as photographs show it without whitening. The bird in left-hand bottom corner is evidently a recent production." This is probably the true explanation. The surface of one stone has undergone more weathering than the other because it is of an older date. The texture of the stone is the same, and the exposition identical. It may be argued that this Karroo dolerite, in spite of its hard texture, weathers away very rapidly, or that the depth of the engravings will greatly depend on the depth of the crust of the surface. But the depth of the pointing does not vary much in the engravings from the neighbourhood of the Orange River Colony observed by or sent to me by Mr. Parkinson. The tools used for the work have been found *in situ*. They are flakes with well-rounded, uneven, worn-out points, made from a shale hardened by the intrusion of dolerite, and they have a very distinct patination. On one very large boulder, the smooth surface of which bears the reproduction of a rhinoceros, and also of probably a zebra, *which are no longer clearly defined*, the crust of the under surface on which the boulder rested is of the same thickness as that of the smooth upper surface, although it was certainly more protected in that situation from weathering agencies, and the wearing away of the engraving must have taken a very considerable time. There is also another reason why some of these inscriptions should prove to be very ancient. They are not always found on the Karroo dolerite mentioned above, but also on the *glaciated* surface of diabase rocks forming at Riverton the bed, and at other places the banks of the Vaal River. They have not been obliterated either by the flow of water or by ordinary weathering. There is no reason to believe that the etchings were originally much deeper than the striated glacial lines, but some of them have become very faint. In the Victoria West District the engravings are hardly distinct from the background.

Another kind of technique is recorded by Mr. M. J. Jackson, who states * that while on patrol some thirty-five years ago among the kloofs of the Zwartberg, in the Kenhardt District, Cape Colony, he found a fine engraving *in relief* of an antelope. That is to say, the surroundings of the outline had been chipped away. I have not been able to trace any specimens of this kind.

Rock-engravings made by line drawings are also found in the Cape Colony. My friend, Mr. H. C. Schunke-Hollway, made copies in 1873 at Jagdpanfontein in the district of Kenhardt, Cape Colony, of a number of these. He is quite sure that the engravings were not pointed or punched. In this locality the variety of figures depicted is great. Next to faithful reproductions of an ass-like animal, possibly a zebra, an eland, a kudu, a multi-striped zebra, inferior, however, in delineation to the examples I have mentioned or figured, are depicted fanciful representations of a chameleon, 14 inches long, with its huge tongue protruding, and having a long, erect mane, and the tail of a baboon; a monitor (*Varanes*) has a crest over its nose; a wart-hog (*Phacochærus*) has a third tusk in the shape of a mark of interrogation curving above its head; an eland has a bifid horn shorter than the ears, and is adorned with two twisted appendages in the centre of the face, while an antelope, which, like the eland, is otherwise fairly delineated, bears instead of horns a straight process divaricating at right angles at the top, &c.

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* Return showing the Districts and the places within them in which Bushman paintings are known to exist.—*Parliamentary Paper*, 1906.

An examination of these line engravings could, alone, enable one to judge if the technique of the work is really very dissimilar from the engravings done by pointing. I am informed that in the Prince Albert District line engravings, very shallow, are of common occurrence, but as the sketches shown me are those of a woman with European dress, &c., and the lines are merely scratched, they need not be taken here into consideration. Mr. Parkinson informs me that after he had shown some of the men on the farm, hybrid Korannas, the engraved rocks, one of them set immediately to carve one *in line*, but it was a man on horseback.

Fig. 15.

It is worthy of note that the figures of man are very poor in design, and very inferior to those of the animals. Mr. A. du Toit, of the Cape Geological Survey, has very kindly sketched for me the engraving at Warrenton, on the Vaal River, of what appears to be the figure of a baboon in an erect, semi-human attitude; associated with it is a zebra conspicuously striped all over the body. At

Jagdpanfontein there is depicted a man with a malformation of one hand, and provided with an enormous phallus not represented in the figure (Fig. 15).

This is another point of similitude with the "rupestres" mentioned by Foureau, *loc. cit.*, p. 1096.

Stowe, in his book, "The Native Races of South Africa," London, 1905, p. 12, says: "The Bushman tribes with regard to their artistic talents were divided into painters and sculptors, and judging from the relics they have left of their former ownership they entered the widespread territories of South Africa by two different lines of migration. The sculptors moved to the southward as far into the Cape Colony as Beaufort West and the Sneeuwberg. The painters, on the other hand, appear to have advanced through Damaraland along the western coast; on arriving at the great mountain ranges in the south, they turned to the eastward, in which direction they can be traced as far as the mountains opposite Delagoa Bay."

I am of opinion that there is no foundation for a theory based on such artistic considerations, because rock-paintings occur also in places where rock-engravings are found. We know also from the subjects depicted that some of these Bushman paintings have been made within recent times. Such an one is a picture in the Cradock District, Cape Colony, of European soldiers on the march, with the commanding officer on horseback, men with the "bear skin," sappers, &c. This probably represents the landing or parading of English troops at Port Elizabeth at the time of the settlement there. But there is no evidence that "rock-engravings" were made lately.* It is possible, however, that both the arts may have been known or practised at the same time by the same people. The paintings would have decayed, the engravings remained well-nigh imperishable. This possibility would, at first sight, be borne out by the discovery, quite lately made by Mr. J. M. Bain, of a "rock-carving" painted over with red ochre, in the Humansdorp District of the Cape Colony. The place on which this engraving was found is in a narrow gorge, where game pits with the stakes at the bottom were still preserved, and disposed in such a way that a driven animal, if it avoided one could not but fall in the other. It is also equally possible that the bedizening of the engraved part is comparatively a recent act.

The comparison of some of the rock-engravings of Southern Algeria and of those of the Sudan with those of Southern Africa, the technique, the subjects reproduced, are strong evidences that the aborigines of the North and those inhabiting at one time South Africa were of one race. The great antiquity of the race that once inhabited Southern Algeria is proven by its representation of prehistoric extinct animals, and representations of such a gigantic size and of extinct animals have not yet been discovered in South Africa it is true, although here also we had a buffalo probably more gigantic still than the one depicted in Northern Africa. But there is evidence all over South Africa of a *palæolithic* Stone Age which cannot be attributed to a Bushman race, and which finds its exact counterpart in Northern Africa and also in the Congo Region. On the other hand, we have also evidence here of a *neolithic*, a recent age, which is ascribable to the Bushman or Strand-Looper, in the shape of the very minute stone implements with numerous secondary chippings, used for boring small disks of ostrich shells. Identical implements and similarly bored ostrich-shell beads are found in Algeria, Tunis, Egypt, the Sudan, and Abyssinia.*

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* Rev. Westphal, of Iniel, on the Vaal River, assures me that he has seen there a rock-engraving representing a mounted man in the act of seizing a man in flight.

Nor must it be forgotten that the date of the history of Egypt is receding more and more as new discoveries are made; that there existed a pre-dynastic race which retained many of the physical attributes of our modern Bushmen and Hottentots, and that many scientific men of repute are of opinion that these Bushmen, or Hottentots, as we call them here, are the remnants of that race which have moved southward.

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* I mention here only one case in point. The others are dealt with in another paper.

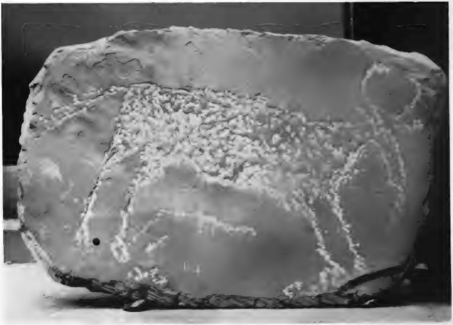


Fig. 1.—390 × 270 mm.

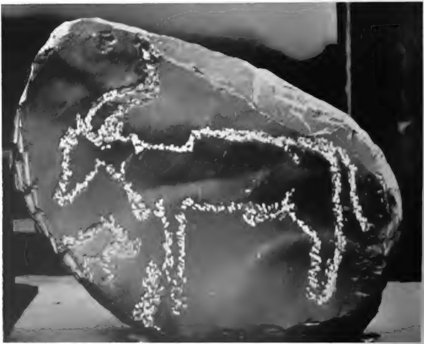


Fig. 2.—250 × 220 mm.

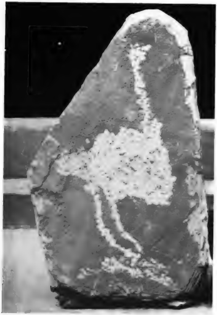


Fig. 4.—135 × 23 mm.

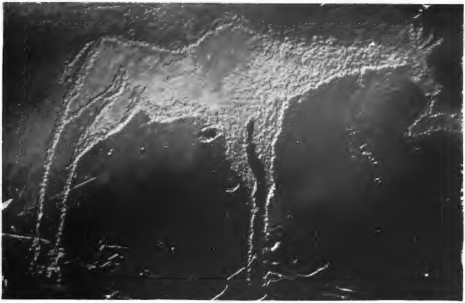


Fig. 3.—620 × 440 mm.

West, Newman, London.

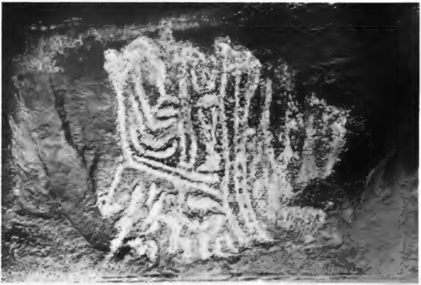


Fig. 5.—300 × 210 mm.

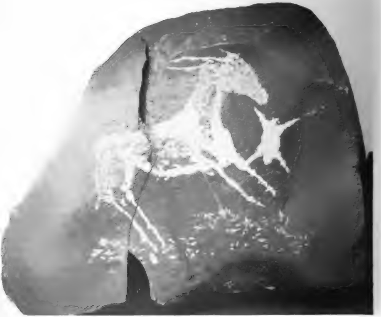


Fig. 6.—500 × 420 mm.

Google

Plate XIII.

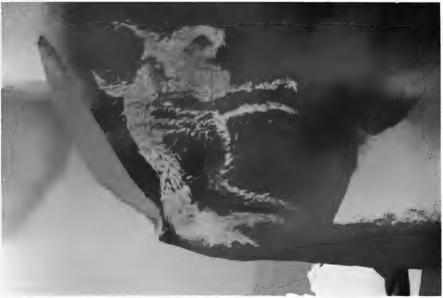
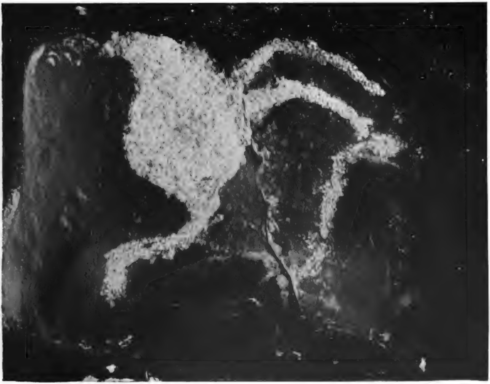


Fig. 8.—230 × 350 mm.



West, Newman, London.

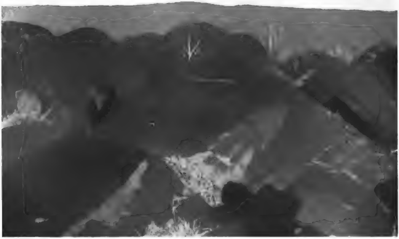


Fig. 9.

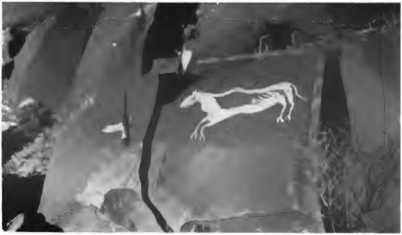


Fig 10.

West, Newman, London.

SOME UNDESCRIBED GENERA AND SPECIES OF SOUTH AFRICAN RHYNCHOTA.

By W. L. Distant.

So far as I am aware this short paper contains the first record of the Family *Phymatidæ* being found in the Ethiopian region, and as the two species here described must necessarily constitute a very meagre representation of these interesting insects, it is to be hoped that South African entomologists at least will endeavour to increase our knowledge.

Little is known of the Homopterous fauna of this region beyond the Cicadidæ and the larger Fulgoridæ; I therefore cannot help appealing to the same quarter for help in the elucidation and record of these somewhat neglected insects.

HETEROPTERA.

Family PHYMATIDÆ.

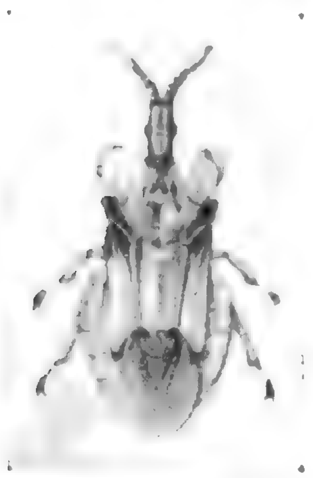
NARINA, gen. nov.

Head long, margins subparallel, postocular portion a little longer than the anteocular; ocelli placed a little nearer to base than to eyes; antennæ short, robust, basal joint about as long as from eyes to apex of head, robust, coarsely granulate, second and third joints short, cylindrical, apical joint longest, fusiform, distinctly narrowed at apex, a little narrowed at base; rostrum extending to about middle of prosternum, first joint robust, nearly reaching middle of postocular portion of head, second joint a little shorter than first, apically narrowed and passing base of head, third joint short and slender, about half the length of second; prosternum channelled for the reception of the rostrum; pronotum sinuately narrowed to apex from lateral angles which are prominent and apically subtruncate, lateral margins obscurely crenulate, anterior angles subprominent, anterior margin truncate, posterior margin subtruncate and about as wide as base of scutellum, disk with two central slightly diverging carinations; scutellum considerably longer than half the length of abdomen, its apex a little narrowed and convexly rounded, its lateral margins strongly carinate; abdomen moderately convexly rounded on each side; membrane slightly passing abdominal apex; anterior coxæ longest. Allied to the Oriental genus *Amblythyreus*, Westw.

Type: *N. capensis*, Dist.

NARINA CAPENSIS, sp. n.

Stramineous; head, disk of pronotum, broad apex to scutellum, membrane, and first, second, and third joints of antennæ pale castaneous; lateral and basal margins of head, narrow anterior margin, four discal spots in transverse series, lateral posterior angles, and posterior margin of pronotum, broad basal angles and narrow apical angles of corium, and a small subapical spot on each lateral margin of scutellum, piceous; apices of intermediate and posterior tarsi black; antennæ granulate, the first and second joints more prominently so; head and pronotum finely and somewhat greyishly granulate, the latter levigate on anterior disk and near anterior lateral margins and with two short discal posteriorly divergent narrow discal carinations, apices of posterior lateral angles subtruncate; scutellum reticulately granulate, the apex rugose; corium finely wrinkled and punctate; connexivum granulose.

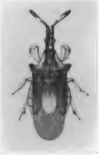


Long. 8½ mm.; exp. pronot. angl., 3 mm.

Hab. Cape Good Hope; Table Mountain (W. Bevins—Brit. Mus.).

NARINA ELIZABETHA, sp. n.

Purplish-red; basal joint of antennæ, anterior, posterior, and lateral margins of head, two short fasciæ on anterior area of pronotum, and two spots and a short central line on its posterior area, and the apical angles of the corium, black; lateral margins (broadly) and posterior margin (narrowly) of pronotum, connexivum, body beneath and legs stramineous; a black spot behind the anterior coxæ, and a central, discal, ventral, purplish fascia; basal joint of antennæ very coarsely granulose, the apical joint somewhat piceous near apex; head coarsely granulose on lateral and posterior margins; pronotum finely granulose, with two discal carinations on anterior area, apices of the posterior angles obliquely subtruncate; scutellum granulose, its apical area mutilated in specimen described as shown by the pale area in the figure; corium finely punctate; membrane with a slight purplish tint; extreme edge of connexivum finely granulose.



Long. 9½ mm.; exp. pronot. angl., 3 mm.

Hab. Cape Colony; Port Elizabeth (Coll. Dist.).

HOMOPTERA.

Family **FULGORIDÆ.**

Sub-Family **DICTYOPHARINÆ.**

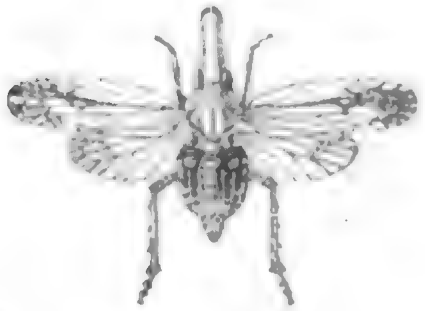
ENGELA, gen. nov.

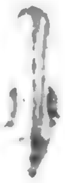
Head very robustly prolonged, incompletely tricarinate, lateral margins carinate; face with the margins subparallel, tricarinate, the carinations not reaching the clypeus; clypeus distinctly centrally carinate; pronotum about as long as eyes, tricarinate; mesonotum about twice as long as pronotum, strongly tricarinate; legs cylindrical, posterior tibiæ with three spines and posterior tarsi moderately dilated; tegmina about three times as long as broad, the veins more or less reticulate on apical area; wings narrow, apical area defined by two discal transverse veins.

Type: *G. minuta*, Dist.

ENGELA MINUTA, sp. n.

Body and legs ochraceous or virescent, carinæ to pro- and mesonota pale virescent; abdomen with the base and the central lateral areas castaneous, the latter intersected with two longitudinal series of pale spots; femora with castaneous longitudinal lines; posterior tibiæ with three spines tipped with black; cephalic process long and very robust, about as long as abdomen, above, with two fine longitudinal carinations which are ampliated at region of eyes, between these a short obscure basal carination, apex a little globose and spotted with dark castaneous; face tricarinate, pro- and mesonota tricarinate, the carinations percurrent; tegmina and wings subhyaline, talc-like, tegmina with the radial vein and the apical area fuscous brown, the latter palely broken between the veins; stigma pale stramineous; wings with the venation fuscous brown, and the apex slightly shaded with the same colour.





Long. excl. tegm., 6 mm.; exp. tegm., 12 mm.

Hab. S. Africa (Mansell Weale—Coll. Dist.).

PUTALA TRANSVAALIENSIS, sp. n.

Head, pronotum, body beneath and legs dull ochraceous; mesonotum brownish ochraceous; abdomen above castaneous-brown, with two central longitudinal series of ochraceous spots, and with three longitudinal series of small greyish-white spots on each lateral area; legs linearly streaked with castaneous, posterior femora subapically spotted with castaneous; cephalic process about as long as pronotum and mesonotum together, a little upwardly recurved; face long, narrowed anteriorly, gradually widened posteriorly from eyes, tricarinate, the lateral carinations scarcely extending in front of eyes; clypeus globose, strongly centrally and marginally carinate, its apex more or less castaneous; posterior tibiæ with five spines of which the three basal spines are placed more closely together, their apices black; pronotum tricarinate with a small foveate spot on each side of the central carination; mesonotum tricarinate; tegmina hyaline, basal venation ochraceous, extreme margins fuscous, on apical area all the transverse veins are infuscate, the upper apical area including the stigma dark fuscous brown; wings hyaline, the extreme margins and venation of apical area fuscous.

Long. excl. tegm., 6½–7 mm.; exp. tegm., 13–15 mm.

Hab. Transvaal (Brit. Mus.); Pretoria (Coll. Dist. and Pret. Mus.).

Allied to *P. apicata*, Melich. from North-East Africa, but differing from the description of that species by its much smaller size, different markings, &c.

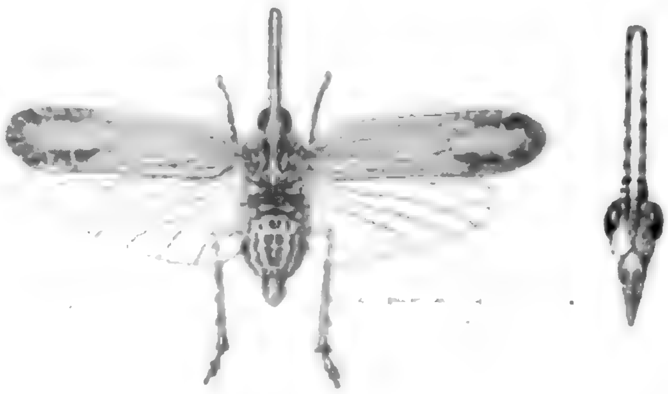
RHABA, gen. nov.

Cephalic process long, slender, of about equal breath throughout from before eyes to apex, margins carinate, under side or face only slightly extending behind eyes, its lateral margins crenulate, its disk sulcate, between eyes the head is hollowed between the carinate margins; clypeus globose centrally obscurely carinate; pronotum about as long as eyes, centrally strongly carinate; mesonotum about twice as long as pronotum, finely tricarinate; abdomen moderately long; anterior tibiæ not dilated; posterier tibiæ with four spines the basal one short; rostrum reaching the posterior coxæ; tegmina long, more than three times longer than broad, venation longitudinal to apical area where there are transverse veins; wings much broader than tegmina.

Type: *A. fasciata*, Dist.

RHABA FASCIATA, sp. n.

Head ochraceous, the lateral ridges to anterior process above black, and beneath spotted with black; pronotum brownish-ochraceous with a central pale ochraceous fascia; mesonotum black with a central longitudinal pale ochraceous fascia, the lateral carinations also of the same colour; abdomen above black with two waved macular ochraceous fasciæ on each lateral area, the lateral margins spotted



with the same colour; body beneath and legs ochraceous, lateral margins of sternum spotted with black; tegmina very pale ochraceous, semi-hyaline, apical area marginally broadly fuscous, commencing at stigma, continued round apex, and terminating on inner margin near end of clavus, this fuscous coloration broken by paler venation; wings pale hyaline; cephalic process long, robust, porrect, from in front of eyes as long as abdomen, above centrally carinate; veins of clavus united before middle; spines to posterior tibiæ concolorous, faintly tipped with black.

Long. excl. tegm., 9 mm.; exp. tegm., 15 mm.

Hab. S. Africa; Namaqualand (Coll. Dist.).

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TRANSACTIONS

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DISCUSSION OF THE ERRORS OF CERTAIN TYPES OF MINIMUM SPIRIT THERMOMETERS IN USE AT THE ROYAL ALFRED OBSERVATORY, MAURITIUS.

By A. Walter, F.R.A.S.,
Chief Assistant.

(Read October 31, 1906.)

Since the year 1902 the corrections to the minimum spirit thermometers in use at the Royal Alfred Observatory, Mauritius, have been obtained from daily comparisons between the readings of the spirit and the corrected readings of a mercurial Standard thermometer, made near the time of minimum temperature, in accordance with the results of the "Investigation of the Degree of Accuracy of Self-registering Maximum and Minimum Thermometers" published in the "Introduction to the Mauritius Magnetical and Meteorological Observations for the year 1901" (p. xxv).

The present discussion was undertaken at the request of the Director of the Royal Alfred Observatory, in view of the occasional large differences between the minimum temperatures, as shown by a minimum spirit thermometer thus corrected, and the lowest points on the thermograms.

Table I. shows the results of the comparisons made during the month of November, 1905.

The minimum thermometer, Casella No. 1,470, was mounted in the Thermograph screen with its bulb at a distance of about 1 foot from the mercurial Standard No. 714, which is used to standardise the photographic records of the Beckley Thermograph, as follows: The observer, while reading the Standard, touches for a few moments the bulb of the Thermograph thermometer, thereby causing a slight temporary dislocation in the photographic curve, so that the exact instant at which the Standard is read is recorded. He then reads the spirit of the minimum thermometer.

TABLE I.

1905.	Lowest point on Thermogram reduced to Standard No. 714. (*a*).	Minimum Temperature as recorded by Casella No. 1,470. (*b*).	(*a–b*).	Time of Minimum Temperature as recorded by Thermograph.	Observed excess of the Readings of the Mercurial Standard No. 714 over those of Casella No. 1,470 used as an ordinary Thermometer at—		Adopted Correction to Casella No. 1,470 according to time of Minimum.	Corrected Minimum by Casella No. 1,470. (*c*).	(*a–c*).
					0h.	6h.			
d.	°	°	°	h. m.	°	°	°	°	°
Nov. 1	62·0	62·9	−0·9	5 35	−1·9	0·0	−0·2	62·7	−0·7
2	60·5	61·4	−0·9	5 40	−1·5	+1·3	+1·1	62·5	−2·0
3	63·9	64·5	−0·6	5 30	−1·3	+0·8	+0·7	65·2	−1·3
4	66·4	67·3	−0·9	5 5	−1·1	+0·2	0·0	67·3	−0·9
5	63·5	64·2	−0·7	4 40	−1·2	−0·3	−0·4	63·8	−0·3
6	62·3	63·4	−1·1	5 15	−0·9	+1·0	+0·7	64·1	−1·8
7	66·1	66·8	−0·7	4 25	−0·8	−0·2	0·0	66·8	−0·7
8	64·9	65·8	−0·9	4 25	−1·0	+0·4	+0·1	65·9	−1·0
9	68·5	69·2	−0·7	4 10	−1·2	−0·1	−0·5	68·7	−0·2
10	68·3	68·7	−0·4	23 0	−1·1	+0·5	−1·1	67·6	+0·7
11	65·5	67·0	−1·5	5 15	−1·0	+1·1	+0·8	67·8	−2·3
12	66·5	67·5	−1·0	5 30	−1·1	+0·9	+0·7	68·2	−1·7
13	66·6	67·7	−1·1	3 35	−1·2	+0·2	−0·3	67·4	−0·8
14	66·6	67·8	−1·2	5 25	−1·1	+0·1	0·0	67·8	−1·2
15	67·6	68·4	−0·8	5 25	−1·1	+0·9	+0·7	69·1	−1·5
16	66·6	67·2	−0·6	5 0	−1·1	+0·5	+0·2	67·4	−0·8
17	66·4	67·2	−0·8	5 15	−0·9	+0·7	+0·4	67·6	−1·2
18	67·7	68·9	−1·2	4 30	−1·1	+1·3	+0·7	69·6	−1·9
19	72·2	72·1	+0·1	23 55	−0·6	−0·3	−0·6	71·5	+0·7
20	71·1	71·0	+0·1	23 0	−0·3	+1·8	−0·3	70·7	+0·4
21	68·1	68·0	+0·1	20 30	−0·4	+0·3	−0·4	67·6	+0·5
22	67·9	68·0	−0·1	15 45	−0·2	+0·1	−0·2	67·8	+0·1
23	67·5	67·8	−0·3	4 20	−0·2	0·0	0·0	67·8	−0·3
24	69·9	70·2	−0·3	1 0	−0·7	+0·3	−0·5	69·7	+0·2
25	70·6	71·0	−0·4	4 45	−0·1	+0·2	+0·1	71·1	−0·5
26	70·4	70·3	+0·1	5 5	−0·2	+0·1	0·0	70·3	+0·1
27	71·0	71·2	−0·2	2 50	−0·6	+0·3	−0·1	71·1	−0·1
28	71·4	71·5	−0·1	3 15	−0·4	−1·1	−0·4	71·1	+0·3
29	72·0	72·0	0·0	6 0	−0·5	0·0	0·0	72·0	0·0
30	67·2	67·3	−0·1	21 0	−0·2	−0·3	−0·2	67·1	+0·1
Mean	—	—	Sum 17·5	—	−0·83	+0·36	—	—	Sum 24·3
Column	1	2	3	4	5	6	7	8	9

The results in Table I. are shown graphically in Fig. 1. It is very apparent that the differences (column 9) between the minimum temperatures (column 8), as recorded by Casella No. 1,470 (reduced to Standard No. 714), and the lowest points on the thermograms (column 1), follow closely the curve of corrections (column 7) derived from simultaneous readings of the spirit and the mercurial Standard; while the sums of the residuals, irrespective of sign, given in column 9, are greater than those in column 3, whereas they should be smaller if the corrections in column 7 are real.

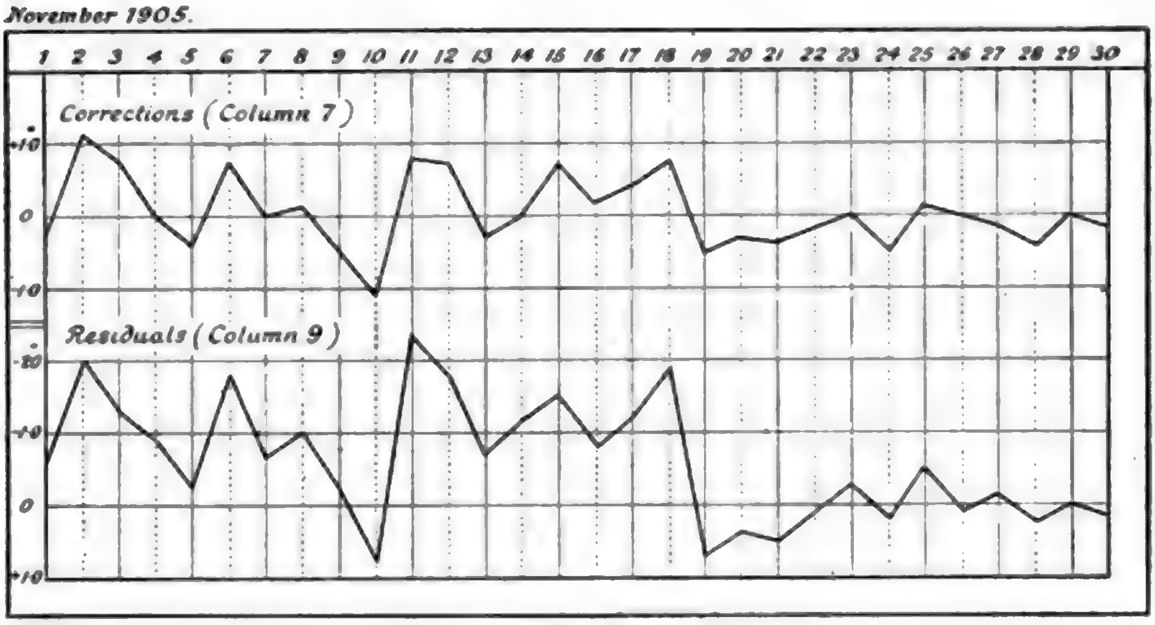


FIG. 1.

In order to ascertain the reason for this undoubted connection between the adopted corrections to the minimum temperatures as recorded by No. 1,470, and the excess of the minima thus corrected, over those obtained from the thermograms, the readings of the spirit at 0h. (midnight) and 12h. (noon) during the three months January to March, 1904, were compared with the corresponding readings of the Kew Standard No. 714, and the differences tabulated for steady falling and rising temperatures respectively. The results are shown in Table II., p. 422.

SUMMARY.

TEMPERATURE.	EXCESS OF STANDARD NO. 714 OVER MINIMUM, CASELLA NO. 1,470.	
Steady	85 observations	− 0·21°
Rising	47 observations	+ 0·10°
Falling	48 observations	− 0·51°

In forming the above tables all available observations were utilised. It will be seen that the correction to reduce the readings of No. 1,470 to the Standard No. 714 is—

+ 0·10° for rising temperatures,
− 0·51° for falling temperatures,

TABLE II.

1904.	Excess of the Readings of Kew Standard No. 714, over those of Casella No. 1,470 (minimum spirit), used as an ordinary thermometer, at—											
	0h. (Midnight).						12h. (Noon).					
	Temperature.						Temperature.					
	Steady.		Rising.		Falling.		Steady.		Rising.		Falling.	
Jan.	2d.	+0·5°			3d.	−0·4°	5d.	+0·1°	2d.	+0·3°	1d.	+0·1°
	4	0·0			5	−0·9	9	−0·1	6	+0·3	3	−0·6
	6	0·0			24	−0·5	18	−0·1	7	+0·4	4	+0·5
	7	0·0			27	−0·8	24	0·0	8	+0·3	10	+0·2
	8	+0·2			30	−0·5	29	+0·1	11	+0·7	12	+0·3
	9	−0·2							13	+0·5	15	+0·1
	10	+0·2							14	+0·6	19	−0·3
	12	0·0							16	+0·4		
	13	+0·2							17	+0·5		
	14	0·0							20	+0·1		
	15	+0·2							21	+0·4		
	16	0·0							22	−0·1		
	17	0·0							23	+0·1		
	18	0·0							25	+0·3		
	19	−0·3							26	+0·2		
	20	−0·5							27	−0·1		
	21	−0·2							28	−0·2		
	22	+0·7							30	0·0		
	23	−0·5							31	0·0		
	25	+0·4										
	26	−0·2										
	28	−0·2										
	29	−0·2										
	31	−0·5										
Sum	24days	+2·4 −2·8			5 days	−3·1	5 days	0·0	19days	+5·1 −0·4	7 days	+1·2 −0·9
Feb.	1d.	−0·3°	5d.	−0·4°	3d.	−0·4°	4d.	−0·3°	2d.	+0·4°	1d.	−0·3°
	2	−0·5	7	−0·1	8	−0·3	5	−0·4	3	0·0	6	−0·4
	4	−0·7			23	−0·9	10	0·0	7	+0·1	9	−0·4
	6	−0·3			28	−1·0	12	+0·1	8	−0·2	11	0·0
	9	0·0			29	−0·1	17	−0·1	13	+0·2	16	−0·4
	10	−1·2					26	−0·7	14	0·0	18	−1·5
	11	−0·1					27	−0·3	15	+0·1	20	+0·1
	12	−0·3							19	−0·1	21	−0·8
	13	−0·2							20	+0·1	22	−0·8
	14	−0·3							28	+0·4	23	−0·4
	15	0·0							29	+0·1	24	−0·9
	16	−0·1										
	17	−0·4										
	18	−0·4										
	19	−0·7										
	20	−0·4										
	21	−0·5										
	22	−0·5										
	24	−0·2										
	25	−0·4										
	26	−0·5										
	27	−0·3										
Sum	22days	−8·3	2 days	−0·5	5 days	−2·7	7 days	−1·8 +0·1	11days	+1·0 −0·7	11days	+0·1 −5·9
March	1d.	0·0°	7d.	−0·5°	4d.	−1·4°	3d.	−0·2°	6d.	+0·8°	1d.	0·0°
	2	−0·2	9	+0·5	5	−0·4	4	−0·4	7	−0·6	2	−0·9
	3	+0·6	17	−0·5	6	−0·9	5	−0·4	8	−0·1	9	−1·6
	10	−0·6	29	−0·3	8	−1·0	13	−0·4	12	−0·4	10	−0·7
	13	−0·6			11	−1·0	14	−0·4	18	+0·2	11	0·0
	14	−0·7			12	−0·8	17	−0·0	23	+0·4	15	−0·7
	16	−0·4			15	−1·0	22	−0·1	24	0·0	16	−0·2
	19	−0·4			18	−0·4	25	−0·5	28	+0·1	19	−0·4
	21	−0·1			20	−0·3	26	−0·3	29	−0·1	20	−0·5
	22	−0·1			28	−0·8	27	−0·0	30	−0·1	21	−0·2
	23	−0·2							31	+0·3		
	24	−0·4										
	25	−0·6										
	26	−0·4										
	27	−0·2										
	30	−0·0										
	31	−0·3										
Sum	17days	−5·2 +0·6	4 days	−1·3 +0·5	10days	−8·0	10days	−2·7	11days	+1·8 −1·3	10days	−5·2
Total	63	−13·3	6	−1·3	20	−13·8	22	−4·4	41	−5·5	28	−10·7
Mean	−0·21		−0·21		−0·69		−0·20		−0·13		−0·38	

which become + 0·31° and − 0·30° respectively, if we consider the correction for steady temperatures (− 0·21°*) to be the true working correction of No. 1,470.

It will also be noticed that the results for "steady temperature" are practically identical at 0h. and 12h., showing that there is no systematic error, due to evaporation and condensation, produced by rising and falling temperatures.

The above results point to the existence of a considerable amount of "lag" in No. 1,470, and are corroborated by observations made during the rapidly changing temperatures which occur in heavy rain showers, the results of which are given below.

TABLE III.

COMPARISONS BETWEEN THE READINGS OF MINIMUM THERMOMETER No. 1,470 AND THOSE OF THE THERMOGRAPH STANDARD No. 714 DURING A RAPID FALL OF TEMPERATURE ON JULY 10, 1906.

Time.			Standard No. 714.	Minimum Thermometer No. 1,470.	Excess of No. 714 over No. 1,470.
h.	m.	s.	°	°	°
12	59	30	72·3	72·8	−0·5
13	0	15	71·4	72·4	−1·0
	1	0	70·4	72·1	−1·7
	1	45	69·4	71·5	−2·1
	2	30	68·9	71·2	−2·3
	3	15	68·6	70·8	−2·2
	4	0	67·9	70·2	−2·3
	4	45	67·8	69·9	−2·1
	5	30	67·4	69·4	−2·0
	6	15	67·1	69·0	−1·9
	7	0	66·9	68·9	−2·0
	7	45	66·9	68·4	−1·5
	8	30	66·8	68·1	−1·3
	9	15	66·7	68·0	−1·3
	10	0	66·8	67·9	−1·1
	10	45	66·7	67·8	−1·1
	11	30	66·6	67·6	−1·0
	12	15	66·7	67·5	−0·8
	13	0	66·9	67·3	−0·4
	13	45	66·9	67·3	−0·4
	14	30	67·0	67·3	−0·3
	15	15	67·0	67·2	−0·2
	16	0	67·1	67·3	−0·2
13	39		68·9	68·2	+0·7
	40		69·5	68·6	+0·9
	41		69·8	68·9	+0·9
	45		70·4	69·5	+0·9

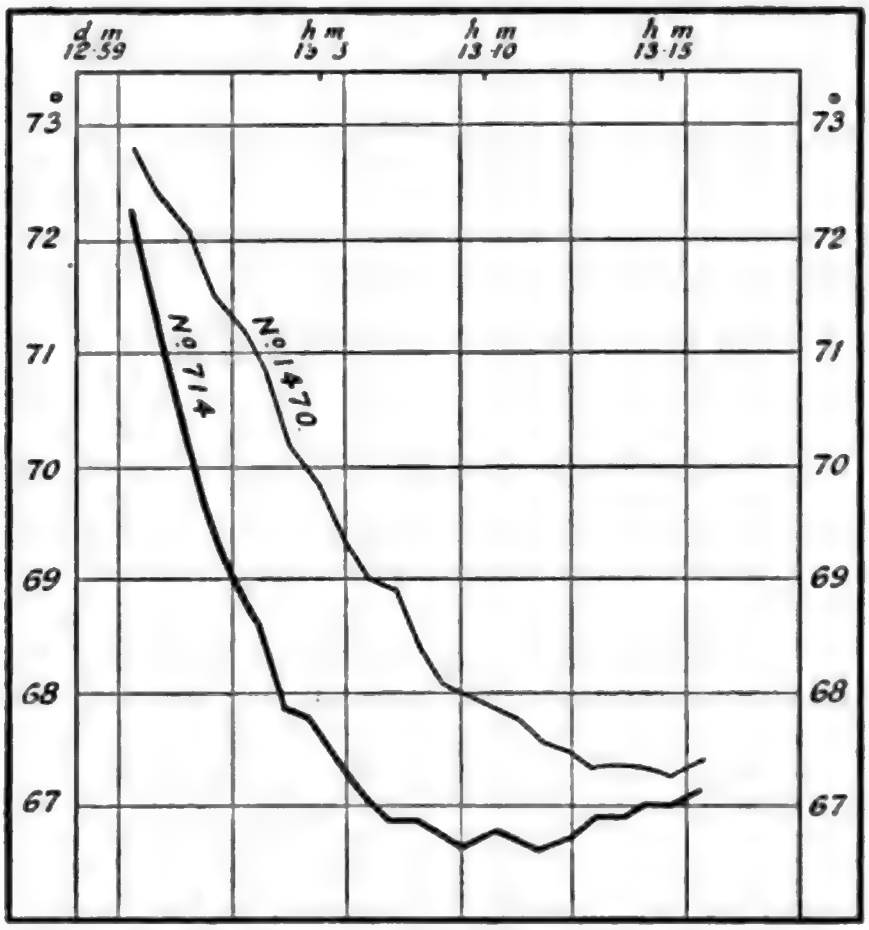
---

* Standard No. 714 has an index error of + 0·11 which has not been applied. This makes the correction to No. 1,470 for steady temperatures − 0·31° (*cf.* p. 434).

In the observations recorded in Table III. and Fig. 2 the effect of changes of temperature were eliminated by reading the thermometers as rapidly as possible in the order 714, 1,470, and 1,470, 714 alternately, and taking the mean of the observations thus obtained.

As the velocity of the wind at this time was thirty-four miles per hour, as recorded by the Dines anemometer, the thermometers were thoroughly ventilated.

Experiments were then made with the object of determining the relative coefficients of sensitiveness of three different types of minimum spirit thermometers—spherical, cylindrical, and divided bulb (see Fig. 4)—as compared with the Kew Standard No. 714.



Rapid Fall of Temperature in a Rain Squall on July 10, 1906, as recorded by the Mercurial Standard No. 714, and the Minimum Spirit Thermometer No. 1,470 respectively.

FIG. 2.

A description of the thermometers employed, together with a history of their errors, will be found on pages 231, 232.

A bath of water was prepared at a temperature of 81° ± (Fahr.), and the thermometers completely immersed in it for five minutes: they were then rapidly removed to the comparison bath at a temperature of 66°± (Fahr.), and the rate of decrease of temperature observed with the aid of a chronometer, care being taken to read each thermometer at the moment of immersion in the low temperature bath. The results of the experiments are given below.

TABLE IV.

Number of Thermometer.	Series.	Time Interval from Moment of Immersion in Comparison Bath. θ	Observed Temperature. t	Temperature of Comparison Bath. τ
		secs.	°	°
Standard (Kew) No. 714.	1	0	80·0 = t_0	66·8
		5·5	71·0	
		13·0	68·0	
		18·0	67·0	
		25·0	66·8	
	2	0	79·0 = t_0	66·7
		3·0	74·0	
		7·0	70·0	
		12·0	68·0	
		22·5	67·0	
		30·0	66·9	
Casella No. 1,470—Type I.	1	0	80·3 = t_0	66·5
		2·0	79·0	
		7·0	78·0	
		10·0	77·0	
		16·5	75·0	
		24·8	73·0	
		30·0	72·0	
		37·0	71·0	
		44·0	70·0	
		56·0	69·0	
		71·0	68·0	
		101·0	67·0	
		118·0	66·8	
	2	0	80·0 = t_0	66·5
		5·5	78·0	
		10·8	76·0	
		15·0	75·0	
		19·0	74·0	
		23·0	73·0	
		28·0	72·0	
		35·0	71·0	
		44·0	70·0	
		56·0	69·0	
		74·0	68·0	
		80·0	67·8	
		90·0	67·6	
		96·0	67·4	
		112·0	67·0	
Darton No. 45,535—Type I.	1	0	81·5 = t_0	67·0
		6·5	78·0	
		12·0	75·9	
		19·0	74·0	
		30·0	72·0	
		38·0	71·0	
		47·0	70·0	
		61·5	69·0	
		87·0	68·0	
Darton No. 45,535—Type I.	2	0	81·0 = t_0	67·0
		4·0	79·0	
		11·0	76·0	
		18·0	74·0	
		23·0	73·0	
		29·0	72·0	
		36·0	71·0	
		46·0	70·0	
		66·0	69·0	
		82·0	68·5	
		103·0	68·0	
	3	0	79·5 = t_0	67·0
		6·0	77·0	
		12·0	75·0	
		16·0	74·0	
		21·0	73·0	
		28·0	72·0	
		36·0	71·0	
		47·0	70·0	
		66·0	69·0	
		80·0	68·5	
		102·0	68·0	
Negretti and Zambra No. 41,178—Type I.	1	0	81·4 = t_0	67·0
		4·0	79·0	
		11·0	77·0	
		18·5	75·0	
		29·0	73·0	
		43·0	71·0	
		53·0	70·0	
		67·0	69·0	
		81·0	68·5	
		95·0	68·0	
	2	0	81·0 = t_0	67·0
		3·5	79·0	
		9·0	77·0	
		13·0	76·0	
		17·0	75·0	
		22·0	74·0	
		28·0	73·0	
		37·0	72·0	
		46·0	71·0	
		59·0	70·0	
		74·0	69·0	
		87·0	68·5	

TABLE IV.—*continued.*

Number of Thermometer.	Series.	Time Interval from Moment of Immersion in Comparison Bath. θ	Observed Temperature. t	Temperature of Comparison Bath. τ
Negretti and Zambra No. 41,178—Type I.	3	secs. 0	° 80·5 = t_0	° 67·4
		3·0	79·0	
		8·0	77·0	
		11·0	76·0	
		16·0	75·0	
		22·0	74·0	
		28·0	73·0	
		35·0	72·0	
		44·0	71·0	
		56·0	70·0	
		65·0	69·0	
		94·0	68·0	
Casella No. 39,833—Type I.	1	0	82·0 = t_0	67·2
		4·0	80·0	
		11·0	77·0	
		17·0	75·0	
		22·0	74·0	
		26·0	73·0	
		30·0	72·0	
		37·0	71·0	
		47·0	70·0	
		61·0	69·0	
		78·0	68·5	
		90·0	68·0	
	2	0	81·0 = t_0	67·5
		3·0	80·0	
		7·0	78·0	
		13·0	76·0	
		20·0	74·0	
		25·0	73·0	
		31·0	72·0	
		39·0	71·0	
		50·0	70·0	
		67·0	69·0	
		74·0	68·5	
		89·0	68·0	
Casella No. 115,511—Type II.	1	0	80·0 = t_0	65·5
		5·4	75·0	
		12·8	71·0	
		26·5	68·0	
		46·0	66·5	
		61·0	66·0	

Number of Thermometer.	Series.	Time Interval from Moment of Immersion in Comparison Bath. θ	Observed Temperature. t	Temperature of Comparison Bath. τ
Casella No. 115,511—Type II.	2	secs. 0	° 80·5 = t_0	° 66·5
		3·0	78·0	
		7·0	75·0	
		12·5	72·0	
		19·0	70·0	
		23·0	69·0	
		29·0	68·0	
		39·0	67·0	
	3	0	80·0 = t_0	66·3
		6·8	75·0	
		12·5	72·0	
		18·8	70·0	
		23·0	69·0	
		29·5	68·0	
		43·0	67·0	
		59·0	66·5	
Hicks No. 175,616—Type III.	1	0	80·0 = t_0	66·4
		3·0	77·0	
		7·5	72·0	
		16·0	69·0	
		22·0	68·0	
		37·0	67·0	
		51·0	66·5	
	2	0	80·0 = t_0	66·4
		3·0	77·0	
		7·5	72·0	
		11·5	70·0	
		18·0	68·5	
		21·0	68·0	
		30·0	67·5	
		37·0	67·0	
		52·0	66·8	
	3	0	79·0 = t_0	66·0
		2·5	77·0	
		10·5	70·0	
		15·0	69·0	
		22·0	68·0	
		31·0	67·5	
		42·0	67·0	

The coefficient of sensitiveness was then computed on the assumption that the relation between the constant temperature τ of the comparison bath, the reading t of the thermometer at any time θ, and the coefficient of sensitiveness λ is represented by the equation—

$$\frac{dt}{d\theta} + \lambda(t - \tau) = 0,^{*}$$

the solution of which gives—

$$(t - \tau) = (t_\circ - \tau)e^{-\lambda\theta},$$

where $t_\circ$ is the value of t when $\theta = 0$.

Curves were drawn from the data contained in Table IV., and values of t read off at intervals $\theta = \theta_1, \theta_2 \ldots \theta_n$, the unit interval being 6 seconds. Substituting the values of t and θ thus found in the expression given above, and taking $t_\circ$ and τ from Table IV., we obtain the following solutions for λ for the several thermometers.

Thermometer	No. 714.			No. 1,470.			
Series	1st and 2nd combined			1st and 2nd combined			
$t_\circ$ τ	79°·50 66·75			80°·17 66·50			
θ	secs. 6	secs. 12	secs. 18	secs. 6	secs. 36	secs. 66	secs. 96
t λ	70°·80 ·191	68°·00 ·194	67°·16 ·191	77°·85 ·031	70°·93 ·031	68°·30 ·031	67°·10 ·033
Mean λ	0·192			0·031			

Thermometer	No. 45,535.											
Series	1st				2nd				3rd			
$t_\circ$ τ	81°·5 67·0				81°·0 67·0				79°·5 67·0			
θ	secs. 6	secs. 24	secs. 42	secs. 60	secs. 6	secs. 24	secs. 42	secs. 60	secs. 6	secs. 24	secs. 42	secs. 60
t λ	78°·3 ·042	73°·0 ·037	70°·5 ·034	69°·1 ·032	77°·9 ·042	72°·8 ·037	70°·4 ·034	69°·2 ·031	77°·0 ·037	72°·5 ·034	70°·4 ·031	69°·2 ·029
Mean λ	0·036				0·036				0·033			

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[*] Chree's "Notes on Thermometry," Phil. Mag., 1898.

Thermometer	No. 41,178.														
Series	1st					2nd					3rd				
t_0	81·4°					81·0°					80·5°				
τ	67·0					67·0					67·4				
θ	secs. 6	secs. 24	secs. 42	secs. 60	secs. 78	secs. 6	secs. 24	secs. 42	secs. 60	secs. 78	secs. 6	secs. 24	secs. 42	secs. 60	secs. 78
t	78·3°	73·9°	71·1°	69·4°	68·5°	78·0°	73·6°	71·4°	69·9°	68·8°	77·6°	73·6°	71·2°	69·7°	68·9°
λ	·040	·031	·030	·030	·029	0·40	·031	·028	·026	·026	·042	·031	·029	·029	·028
Mean λ	0·032					0·030					0·032				

Thermometer	No. 89,833.									
Series	1st					2nd				
t_0	82·0°					81·0°				
τ	67·2					67·5				
θ	secs. 6	secs. 24	secs. 42	secs. 60	secs. 78	secs. 6	secs. 24	secs. 42	secs. 60	secs. 78
t	78·9°	73·3°	70·5°	69·2°	68·4°	78·4°	73·2°	70·9°	69·3°	68·4°
λ	·037	·037	·036	·033	·032	·036	·036	·033	·034	·035
Mean λ	0·035					0·035				

Thermometer	No. 115,511.														
Series	1st					2nd					3rd				
t_0	80·0°					80·5°					80·0°				
τ	65·5					66·5					66·3				
θ	secs. 6	secs. 12	secs. 18	secs. 24	secs. 30	secs. 6	secs. 12	secs. 18	secs. 24	secs. 30	secs. 6	secs. 12	secs. 18	secs. 24	secs. 30
t	74·5°	71·2°	69·5°	68·4°	67·7°	75·5°	72·3°	70·2°	68·7°	67·9°	75·5°	72·1°	70·2°	68·8°	67·9°
λ	·079	·078	·072	·067	·063	·074	·073	·074	·077	·077	·066	·072	·070	·071	·072
Mean λ	0·072					0·075					0·070				

Thermometer	No. 175,616.							
Series	1st and 2nd combined				3rd			
t_0	80·0°				79·0°			
τ	66·4				66·0			
θ	secs. 6	secs. 12	secs. 18	secs. 24	secs. 6	secs. 12	secs. 18	secs. 24
t	73·1°	69·9°	68·5°	67·8°	73·2°	69·6°	68·5°	67·9°
λ	·118	·113	·104	·095	·098	·107	·092	·080
Mean λ	0·107				0·094			

TABLE V.

SUMMARY.

Type of Thermometer.	Maker and Number of Thermometer.	Mean λ.
Mercurial—Kew Standard	Kew 714	0·192
Minimum Spirit, Type III.	Hicks 175,616	0·101
,, ,, Type II.	Casella 115,511	0·072
,, ,, Type I.	Darton 45,535	0·035
,, ,, ,, ...	Casella 89,833	0·035
,, ,, ,, ...	Negretti and Zambra 41,178	0·031
,, ,, ,, ...	Casella 1,470	0·031

TABLE VI.

RATIO OF THE COEFFICIENT OF No. 714 TO THAT OF EACH TYPE OF MINIMUM THERMOMETER EMPLOYED.

No. 714.	$\frac{\text{No. 714.}}{\text{Type I.}}$	$\frac{\text{No. 714.}}{\text{Type II.}}$	$\frac{\text{No. 714.}}{\text{Type III.}}$
0·192	5·82	2·67	1·90

The values of λ found above are not necessarily the actual working coefficients of these thermometers, the conditions under which they were determined differing entirely from those to which they are exposed in meteorological investigations; but they serve the purpose of this discussion in giving approximately comparative values for the different thermometers employed.

It would appear, moreover, from the persistent decrease in the computed value of λ, that for some thermometers at least, with the value of $(t - \tau)$ employed, the relation between t, τ, λ, is not correctly given by the equation—

$$\frac{dt}{d\theta} + \lambda (t - \tau) = 0;$$

but at the same time it should be remembered that the generally large value of λ found for the interval $\theta = 6$ secs., depends on a portion of the curve where t is decreasing rapidly, and where, in consequence, an error of a few tenths of a second in θ will give large errors of t.

Curves, derived from the data given in Table IV., indicating the degree of sluggishness of the several types of thermometers employed are given in Fig. 3.

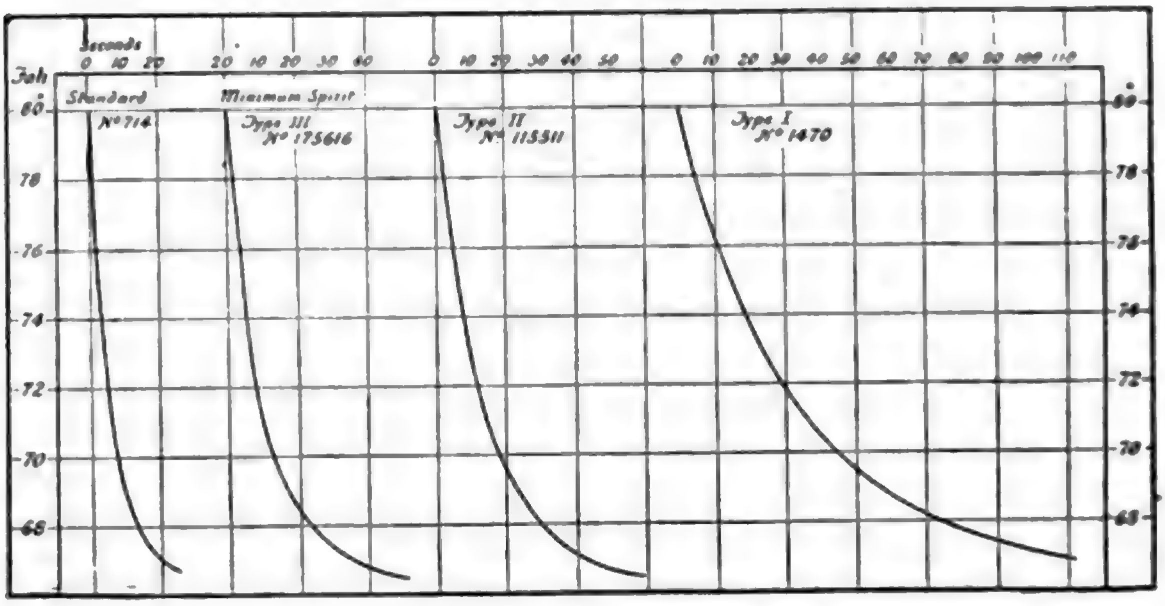

FIG. 3.

In the following tables will be found the details of the construction of each thermometer, together with the errors as determined at Kew and at the Royal Alfred Observatory, Mauritius.

TABLE VII.

Type of Thermometer.	Maker and Number of Thermometer.	Date of Kew Certificate.	Bulb.			Value of 10° in millimetres.			Coefficient of Sensitiveness.
			Shape.	Length.	Diameter.	From 85° to 75°	From 75° to 65°	From 65° to 55°	
Mercurial	Kew Std. No. 714	April, 1894	Cylindrical	mills. 90	mills. 7	21	21	21	0·192
Min. (ordinary) colourless spirit	Casella No. 1,470	April, 1859	Spherical	—	18	19·8	19·1	18·8	0·031
,, ,, ,, ,,	Darton No. 45,535	Aug., 1894	,,	—	14	14·1	13·5	13·0	0·035
,, ,, ,, ,,	Negretti No. 41,178	April, 1878	,,	—	16	15·0	14·7	14·1	0·031
,, ,, red spirit	Casella No. 115,511	April, 1899	Cylindrical	27	7·7	15·9	15·9	15·9	0·072
,, (grass) colourless spirit	Casella No. 89,833	April, 1893	Spherical	—	15·5	16·0	15·8	15·2	0·035
Sensitive minimum (grass) colourless spirit	Hicks No. 175,616	Oct., 1884	Hollow Cylindrical	60	external 11·5 internal 4	18·2	17·8	17·4	0·101

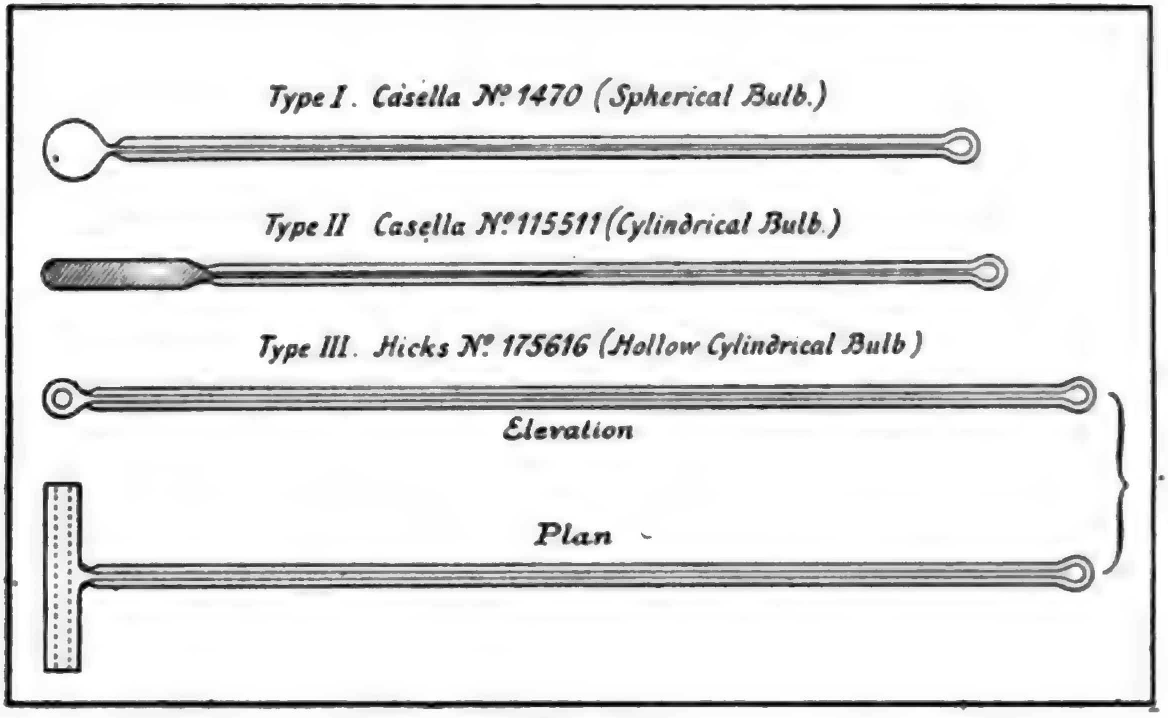
Type I. Casella Nº 1470 (Spherical Bulb.)
Type II Casella Nº 115511 (Cylindrical Bulb.)
Type III. Hicks Nº 175616 (Hollow Cylindrical Bulb)
Elevation
Plan

Fig. 4.

Corrections to the Thermometers employed, derived from Comparisons (in Water) with the Kew Standard No. 701.

Thermometer No. 714.	Correction.
1894 at Kew	0·0°
1895 at Mauritius	−0·02
1898 ,,	−0·04
1901 ,,	−0·09
1904 ,,	−0·11

Thermometer No. 1,470.	Correction.
1859 at Kew	0·0°
1879 at Mauritius	+0·1
1889 ,,	0·0
1899 ,,	0·0
1906 ,,	0·0

Thermometer No. 45,535.	Correction.
1894 at Kew	0·0°
1906 at Mauritius	−0·7

Thermometer No. 41,178.	Correction.
1878 at Kew	0·0°
1902 at Mauritius	+0·3

Thermometer No. 115,511.	Correction.
1899 at Kew	0·0°
1900 at Mauritius	+0·1
1901 ,,	+1·0
1902 ,,	+0·7

Thermometer No. 89,833.	Correction.
1893 at Kew	+0·1°
1895 at Mauritius	+0·3
1897 ,,	−0·1
1899 ,,	0·0
1902 ,,	−0·2

Thermometer No. 175,616.	Correction.
1884 at Kew	0·0°
1888 at Mauritius	+0·6
1892 ,,	+0·6
1896 ,,	+1·4
1902 ,,	+4·0

The corrections to the minimum temperatures, recorded by No. 1,470, for the three months—1904, January to March—already dealt with, as determined from comparisons with the lowest points on the thermograms, are given in the following table—

(1) When the minimum occurred at the apex of a sharp wave.

(2) When either the approach to, or recovery from, the lowest point was gradual and the minimum lasted from five to ten minutes :—

1904.											
January.				February.				March.			
Correction to the Minimum Temperature recorded by No. 1,470 when it occurred at—											
The Apex of a Sharp Wave.		A Period of Steady Temperature.		The Apex of a Sharp Wave.		A Period of Steady Temperature.		The Apex of a Sharp Wave.		A Period of Steady Temperature.	
d.	°	d.	°	d.	°	d.	°	d.	°	d.	°
2	−0·2	4	+0·3	2	−3·0	1	−0·3	1	−0·5	2	+0·1
3	−2·2	5	−0·2	4	−0·6	3	−0·6	4	−0·3	3	−0·5
10	−0·2	6	0·0	5	−0·6	6	−0·4	6	−0·5	5	−0·5
11	−0·4	7	+0·2	7	−1·6	10	−0·1	8	−0·1	7	−0·4
19	−0·6	8	0·0	8	0·0	12	−0·4	11	−0·9	9	−0·3
24	−0·3	9	−0·1	9	−1·3	16	−0·8	12	−0·6	10	−0·6
25	−1·4	12	+0·2	11	−0·3	17	−0·2	18	−0·2	13	−0·3
27	−0·8	13	−0·1	15	−0·3	19	−0·7	21	−0·3	14	−0·4
		14	−0·1	21	−0·7	20	−0·6			15	−0·6
		15	+0·1	22	−0·6	24	−0·4			16	−0·2
		16	−0·3	23	−0·8	26	−0·4			17	−0·3
		17	−0·2	27	−1·5	28	+0·4			23	−0·6
		18	−0·4			29	−0·0			24	−0·4
		20	−0·5							25	−0·6
		21	−0·6							30	+0·1
		22	0·0							31	−0·1
		23	−0·1								
		26	+0·3								
		28	+0·1								
		30	+0·5								
		31	−0·3								
8d.	−0·76	21d.	−0·06	12d.	−0·94	13d.	−0·31	8d.	−0·43	16d.	−0·35

Summary.

1904. Month.	Correction to the Minimum Temperature recorded by No. 1,470 when it occurred at—			
	The Apex of a Sharp Wave.		A Period of Steady Temperature.	
	Mean Correction.	Maximum Correction.	Mean Correction.	Maximum Correction.
	°	°	°	°
January	−0·76	−2·2	−0·06	−0·6
February	−0·94	−3·0	−0·31	−0·7
March	−0·43	−0·9	−0·35	−0·6

The mean correction to No. 1,470 by this method is −0·22°, which corrected for index error of standard becomes −0·32° (*cf.* pp. 423 and *infra*).

The results given in the above table are in entire agreement with those already obtained, and call for no further remark beyond pointing out the very serious nature of these errors, which all tend in the same direction, *i.e.*, to give an erroneous minimum considerably higher than the true one.

The present investigation leads us to the following conclusions * :—

1. Minimum spirit thermometers (even the so-called "sensitive") should never be used as ordinary thermometers.

2. The corrections to the minimum temperature obtained from comparisons between the readings of the spirit and the readings of a mercurial standard, unless made at an epoch of steady temperature, are unreliable, and may, in extreme cases, be in error to the extent of 2° or more.

3. The corrections obtained at steady temperatures from comparisons made as described above, compare favourably with those obtained from comparisons with the lowest points on the Thermograms; but do not, apparently, agree with those obtained in the usual way from comparisons in water (*cf.* pp. 423, 432 *et supra*).

4. The absolute minima obtained with spherical bulb thermometers are frequently in error on account of sluggishness, the errors in extreme cases amounting to as much as +3°.

5. The mean of the absolute minima obtained with spherical bulb thermometers is invariably too high, as all errors due to sluggishness tend in the same direction.

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* This is only intended to apply to the types of thermometers employed in this discussion; it is quite possible that, at other stations, minimum thermometers of greater sensitiveness are in use. It should, however, be remarked that three spherical bulb thermometers made by different makers in the years 1859, 1878, and 1894 respectively give practically the same value of λ.

6. The absolute minima obtained with cylindrical, hollow-cylindrical, or bifurcated bulbs are probably but slightly affected by "lag," as the approach to or recovery from the lowest point is generally slow enough to allow them to take up the correct temperature.

Assuming that the thermometers employed are fair representatives of their respective types, it seems evident that no spirit thermometer with a spherical bulb should be allowed in the equipment of a meteorological observatory. Hollow-cylindrical bulbs reduce the errors due to sluggishness by about ⅔.

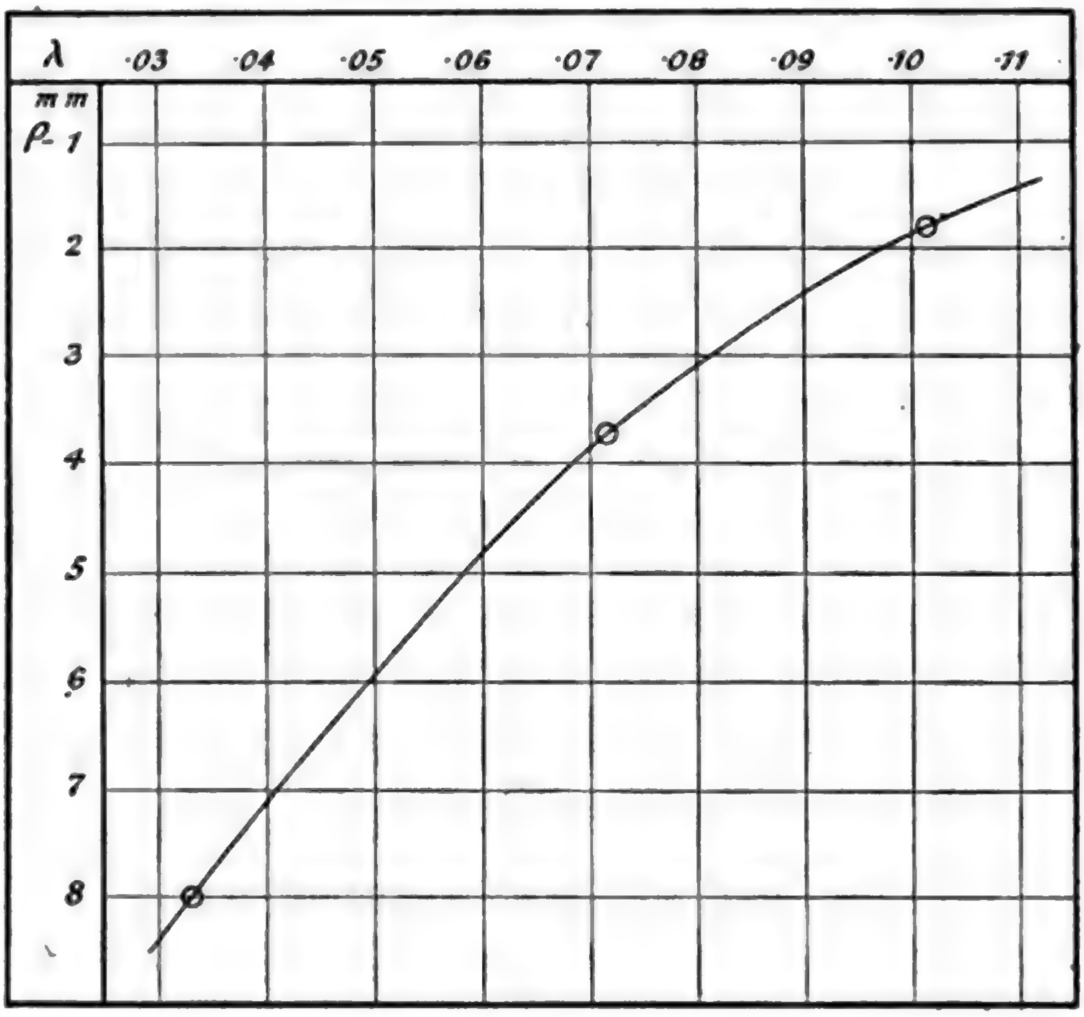

FIG. 5.

In connection with the form and dimensions of the bulb it is interesting to note that the computed values of λ appear to bear a simple relation to the radii of the bulbs, irrespective of their form.

The radii for the several types of thermometers, taken from Table VII., are—

Spherical bulb .... 8 millimetres.
Cylindrical ,, ... 3·8 ,, (radius of base).
Hollow-cylindrical bulb, 1·85 ,, ½ (external radius–internal radius).

If we plot these values as ordinates, with the corresponding values of λ as abscissæ, we obtain a curve of the form given below, which may be represented by the formula :—

$$\lambda = a + b\rho + c\rho^2$$

where ρ is the radius of the bulb and a, b, c constants to be determined.

Substituting the values of λ and ρ, obtained from Table VII., we have—

$$\begin{aligned} \cdot033 &= a + b\,8{\cdot}0 \;\; + c\,64{\cdot}00 \\ \cdot072 &= a + b\,3{\cdot}8 \;\; + c\,14{\cdot}44 \\ \cdot101 &= a + b\,1{\cdot}85 + c\;\;3{\cdot}4225 \end{aligned}$$

the solution of which gives—

$$\lambda = \cdot135 - \cdot020\rho + \cdot00091\rho^2.$$

NOTE ON THE CONNECTION BETWEEN THE RAINFALL AT DURBAN AND MAURITIUS.

By T. F. Claxton, F.R.A.S.,

Director, Royal Alfred Observatory, Mauritius.

(Read October 31, 1906.)

The present notice contains the first results of an inquiry into the possibility of seasonal weather forecasts for Mauritius.

Mauritius weather being controlled to a much greater extent in winter than in summer by the number and intensity of the anticyclones, with their attendant V-shaped depressions, which pass to the south of Mauritius from the Cape towards Australia, it was thought that an examination of the weather conditions to the south-west of Mauritius in the winter months might give some idea of the subsequent weather at Mauritius. Monthly departures from average of the various meteorological elements at Durban were compared with those at Mauritius; the latter were also compared with the monthly departures from average of the pressure gradient between Durban and Mauritius *; but there appeared to be no connection between them.

The next step was to examine the weather conditions at Durban antecedent to winter droughts in Mauritius, and still there appeared to be no connection; but on reversing the argument, examining the weather conditions at Mauritius following droughts at Durban, a connection at once became apparent.

In the following table are given particulars of the droughts which have occurred at Durban since 1873—the year in which observations were commenced—and of the corresponding droughts in Mauritius.

The information for Durban has been extracted from the annual reports of the Government Astronomer, and is based upon rainfall

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* The abnormality curve of pressure gradient follows very closely the abnormality curve of pressure at Durban, the departures from average being so much larger at Durban than at Mauritius.

NATAL.

Period.	Monthly percentage of Normal Rainfall.	Remarks.
1873 April to July	83, 42, 0, 69	
1874 July to October	36, 70, 53, 45	
1876 February to May	23, 59, 168, 21	Daily values not available: ? cause of excess in April.
1876 October to 1878 April	41, 72, 41, 92, 56, 46, 93, 3, 77, 85, 43, 73, 68, 62, 52, 48, 95, 65, 85	The longest drought on record. The nearest approach to normal rainfall occurred in 1877 January, 92 per cent., 1877 April, 93 per cent., and 1878 February, 95 per cent.
1878 July to December	18, 16, 5, 32, 90, 65	Practically a continuation of previous drought.
1880 June to September	70, 0, 50, 31	
1881 February to July	66, 45, 33, 20, 59, 50	
1881 December to 1882 March	63, 73, 39, 54	
1883 June to September	24, 4, 210, 24	Included as a drought provisionally; daily observations may show that the heavy rain in August fell on one or two days only.
1884 July to September	18, 37, 83	
1885 February to 1886 January	50, 58, 68, 57, 35, 3, 44, 267, 63, 72, 83, 70	
1886 August to October	36, 22, 13	
1889 June to 1890 January	32, 20, 91, 28, 93, 45, 26, 44	Total rainfall in August and October nearly normal, owing to somewhat heavy rain on August 17th, 30th, and October 23rd.
1890 May to September	29, 42, 11, 46, 28	Most severe winter drought on record.
1892 March to July	27, 28, 73, 0, 49	
1894 January to March	39, 79, 44	
1094 June to August	82, 87, 27	The whole of the June rainfall occurred from the 25th to the 28th.
1895 May to 1896 June	74, 11, 86, 40, 42, 60, 44, 232, 68, 83, 86, 163, 57, 15, 82	Severe prolonged drought broken by very heavy rain on December 12th to 14th and April 7th.
1897 April to September	34, 17, 535, 2, 65, 120	Severe drought broken by heavy rain on June 8th to 10th and September 10th to 11th.
1898 June to September	66, 28, 150, 51	60 per cent. of the August rainfall occurred on the 5th and 6th; 70 per cent. of the September rainfall occurred on the 30th.
1899 February to 1900 May	29, 83, 45, 91, 24, 56, 17, 43, 144, 46, 75, 89, 56, 48, 47, 22	Severe prolonged drought broken by very heavy rain on October 22nd.
1902 December to 1903 March	82, 56, 52, 83	
1903 July to October	20, 133, 16, 27	Severe drought broken by heavy rain on August 27th. Practically a continuation of previous drought.
1904 August to November	13, 15, 58, 83	

AND MAURITIUS.

Mauritius.			Interval between commencement at Natal and Mauritius (Months).
Period.	Monthly percentage of Normal Rainfall.	Remarks.	
1873 November to 1874 February	57, 89, 78, 50		7
			6
1875 January to April	53, 33, 33, 92		
1876 March to September	58, 59, 81, 88, 85, 71, 82	Followed by a further drought in November, 57 per cent., and December, 76 per cent.	?
1877 December to 1878 March	96, 78, 63, 76		?
1878 October to 1879 February	23, 66, 110, 84, 82		8
1879 October to 1881 March	88, 28, 110, 59, 123, 42, 39, 58, 143, 93, 77, 60, 50, 42, 82, 71, 42, 32	Longest and most severe drought on record.	?
1881 August to October	58, 78, 67		6
1882 April to June	51, 40, 97		4
1884 January to March	83, 55, 84		
1884 June to September	73, 92, 33, 66	Practically a continuation of previous drought.	7
1884 December to 1885 April	19, 64, 49, 66, 70		5
1885 November to 1886 December	67, 82, 42, 58, 40, 86, 62, 61, 96, 38, 44, 104, 66, 48	Very severe prolonged drought broken by normal rains in 1886 October.	9
1889 September to 1890 January	68, 75, 52, 110, 61		3
1890 December to 1891 February	59, 69, 63		7
1893 February to March	53, 62		?
1893 August to December	58, 56, 74, 80, 29		?
1894 February to April	95, 44, 93		?
1894 October to 1895 February	46, 91, 125, 40, 84		4
1896 June to 1897 May	73, 79, 69, 67, 57, 69, 39, 100, 79, 36, 30, 31	Very severe prolonged drought.	?
1897 October to 1898 February	92, 77, 116, 87, 53	Moderate drought broken by rains slightly above normal in December.	6
1898 October to 1899 January	41, 48, 50, 41		4
1899 November to 1900 December	72, 25, 53, 80, 95, 22, 93, 43, 102, 50, 35, 76, 38, 33	Very severe prolonged drought broken by normal rains in July.	?
1903 May to 1904 February	28, 91, 36, 68, 101, 69, 42, 50, 46, 55	The summer drought may be considered to have commenced in October.	5
1904 August to December	49, 72, 73, 50, 59		?

observations made at the Durban Botanical Gardens from 1873–1883 and at the Government Observatory from 1884–1904. It has not been possible to form tables of monthly departures from average rainfall for the whole of Natal. Such tables are, however, very desirable, as the rainfall at Durban, particularly in the winter months, is erratic. Frequently a very dry month will show a rainfall much in excess of normal owing to floods on one or two days.

The information for Mauritius is based upon the returns from ten representative stations in different parts of the island, and may be considered as an accurate numerical statement of the droughts which have occurred.

From the preceding table it will be seen that winter droughts at Durban have invariably been followed by summer droughts in Mauritius at intervals of from three to seven months, and that prolonged droughts at Natal, or those commencing in the summer, may be either accompanied or followed by prolonged droughts in Mauritius.

With a view to ascertaining whether the interval is dependent upon the date of commencement, duration, or intensity at Durban the droughts have been grouped in the following table according to the interval between the commencement of the drought at Durban and in Mauritius.

There is some evidence to show that the interval depends upon the time of commencement of the drought at Durban, the former varying inversely with the latter, in the mean; but the interval, duration, and intensity of the Mauritius droughts appear to be independent of the duration or intensity of the Natal droughts, at least so far as winter droughts are concerned.

There is this connection, however, that whereas winter droughts at Durban are followed by summer droughts in Mauritius, prolonged droughts at Durban lasting over summer and winter, or longer, are either accompanied, or followed, by prolonged droughts in Mauritius.

The first prolonged drought at Durban, which commenced in February, 1876, and lasted practically up to December, 1878, was accompanied by a prolonged drought in Mauritius from March, 1876, to December, and followed by a second very severe drought in Mauritius from October, 1879, to March, 1881.

The second prolonged drought at Durban, from February, 1885, to January, 1886, was accompanied and followed by a prolonged drought in Mauritius from November, 1885, to December, 1886.

The third prolonged drought at Durban, from May, 1895, to June, 1896, was followed by a prolonged drought in Mauritius from June, 1896, to May, 1897.

DROUGHTS GROUPED ACCORDING TO INTERVAL BETWEEN COMMENCEMENT IN NATAL AND MAURITIUS.

Interval (Months).	In Natal.												In Mauritius.								
	Commencement.	Duration (Months).	Percentage of Normal Rainfall in each Month.										Percentage of Normal Rainfall in each Month.								Duration (Months).
			A.	M.	J.	J.	A.	S.	O.	N.	D.	J.	S.	O.	N.	D.	J.	F.	M.	A.	
—	1873 April	4	83	42	0	69	—	—	—	—	—	—	—	—	57	89	78	50	—	—	4
7	1883 June	4	—	—	24	4	210	24	—	—	—	—	—	—	—	—	83	55	84	—	3
—	1890 May	5	—	29	42	11	46	28	—	—	—	—	—	—	—	59	69	63	—	—	3
Means	May 1	4·3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3·3
—	1874 July	4	—	—	—	36	70	53	45	—	—	—	—	—	—	—	53	33	33	92	4
6	1897 April	6	34	17	535	2	65	120	—	—	—	—	—	92	77	116	87	53	—	—	5
Means	May 15	5·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4·5
5	1884 July	3		—	—	18	37	83	—	—	—	—	—	—	—	19	64	49	66	70	5
—	1894 June	3	—	—	82	37	27	—	—	—	—	—	—	46	91	125	40	34	—	—	5
4	1898 June	4	—	—	66	28	150	51	—	—	—	—	—	41	48	50	41	—	—	—	4
Means	June 1	3·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4·5
3	1878 July	6	—	—	—	18	16	5	32	90	65	—	—	23	66	110	34	82	—	—	5
—	1889 June	8	—	—	32	20	91	28	93	45	26	44	68	75	52	110	61	—	—	—	5
—	1903 July	4	—	—	—	20	133	16	27	—	—	—	—	69	42	50	46	55	—	—	5
Means	June 20	6·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5·0

The fourth prolonged drought at Durban, from February, 1899, to May, 1900, was accompanied and followed by a prolonged drought in Mauritius from November, 1899, to December, 1900.

As a large proportion of the summer rainfall at Mauritius is usually of cyclonic origin, the above results suggested that the summers following winter droughts at Durban would be characterised by the absence of cyclones in the neighbourhood of Mauritius, though it would be difficult to give a satisfactory explanation of such a connection. Upon examining the Mauritius records, however, it was found that the mean number of cyclones within the 20° square of which Mauritius is the centre was 3·3 in the summers following winter droughts at Durban, while the mean for all summers since 1873 was 3·8. As the numbers of which 3·3 is the mean varied between 0 and 6, the small difference (3·8–3·3) does not appear to have any real significance, and may possibly have changed sign had a larger or smaller area been considered, or a different number of years used. It appears, therefore, that winter droughts at Durban are not necessarily followed by an absence of cyclones in the neighbourhood of Mauritius, and hence that their effect on the non-cyclonic rain of the following summer in Mauritius is even greater than indicated by the figures given in this paper, and that after such droughts Mauritius is dependent on cyclones to a greater extent than usual for the following summer rainfall.

It remains to be seen whether further observations from stations along the east coast of South Africa will bring to light a still closer connection between the rainfall over this region and in Mauritius. Though no claim is made that an accurate monthly forecast of summer droughts in Mauritius can be made from a study of the rainfall along the east coast of South Africa during the preceding winter, yet it appears from the figures given above that one, if not the principal determining factor has been discovered. As other factors are discovered and the broader effects of solar influences become better understood, it is to be hoped that seasonal forecasts of a fair degree of accuracy will be possible.

THE CHEMICAL COMPOSITION OF BERRY WAX.

By B. de St. J. Van der Riet, M.A., Ph.D.

(Read October 31, 1906.)

Berry wax forms a rough coating on the surface of the berries of *Myrica cordifolia*, a common plant on the sea-coast at the Cape. The berries are collected at the beginning of winter and boiled with water, when the melted wax rises to the surface and solidifies on cooling. Some tons in weight are produced annually and find a ready sale in South Africa, being used for waxing floors.

By warming the crude product a little above 100° C., some steam hisses off, and by filtering, using a hot-water funnel, mechanical impurities such as dust and leaves are separated. The substance thus purified has still a greenish-yellow tint, no doubt due to chlorophyll, and gives off a faint but characteristic herb-like odour.

Berry wax is in reality a vegetable fat and not a true wax. Lewkowitsch[*] describes the "myrtle wax" obtained from various species of *Myrica*, mentioning the species *cordifolia* among others, and implies that they all yield the same substance which, he states, "consists of the glycerides of stearic, palmitic, and myristic acids, and a small quantity of oleic acid." Excepting in regard to the presence of oleic acid, this statement holds good for berry wax.

I have determined certain physical and chemical constants of berry wax, and find that my numbers agree fairly well with those quoted by Lewkowitsch for myrtle wax, as the following table shows :—

	Berry Wax.	Myrtle Wax.[†]
Sp. gr. at 15° C.	1·007	·995 (Allen) ·875 (Allen)
Solidifying point	39°–40° C.	39°–43° C. (Allen)
Melting point	41°–45° C.	40°–44° C. (Allen)
Saponification value (Mgms. Caustic Potash)	214·6	205·7 (Allen) 211·7 (Allen)
Iodine value, per cent.	Nil	10·7[‡] (Mills)

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[*] Dr. J. Lewkowitsch, "Chemical Analysis of Oils, Fats, Waxes, &c.," 1898, p. 542.

[†] Dr. J. Lewkowitsch, "Chem. Anal. of Oils, &c.," p. 543.

[‡] Calculated from bromine value, 6·34.

The only important point of difference to be noted in the above table is in regard to the iodine value, which by Hübl's method I found to be nil in the case of berry wax, indicating the absence of unsaturated acids, including, of course, oleic acid. It appears possible that Lewkowitsch bases his statement regarding the presence of oleic acid on an iodine value calculated from a bromine value, and not on an iodine value directly determined, which alone would be conclusive evidence.

The absence of unsaturated acids in berry wax no doubt accounts for the stability of this fat at comparatively high temperatures. I have for some years found it an excellent material for use in the oil bath. Even after repeated heating the bath compares very favourably with, for instance, melted paraffin wax, giving off very little odour or obnoxious vapour, even at 300° C., and having a very high flashpoint.

VICTORIA COLLEGE, STELLENBOSCH.

A PROPERTY OF AXISYMMETRIC DETERMINANTS, CONNECTED WITH THE SIMULTANEOUS VANISHING OF THE SURFACE AND VOLUME OF A TETRAHEDRON.

By Thomas Muir, LL.D.

1. In a striking and characteristic paper,* published by Sylvester in 1853, he dealt with a consequence of the simultaneous vanishing of the volume and surface of a tetrahedron. Denoting the squared areas of the faces of the tetrahedron by F, G, H, K, and the volume by V, he supposes one of the vertices to become a point in the opposite face, with the result that

$$\left.\begin{aligned}\sqrt{\mathrm{F}}+\sqrt{\mathrm{G}}+\sqrt{\mathrm{H}}+\sqrt{\mathrm{K}}&=0\\ \text{and}\quad \mathrm{V}&=0\end{aligned}\right\},$$

and he thence concludes that if F, G, H, K, V be expressed in terms of one and the same set of variables—say the edges a, b, c, f, g, h of the tetrahedron—the norm of $\sqrt{\mathrm{F}}+\sqrt{\mathrm{G}}+\sqrt{\mathrm{H}}+\sqrt{\mathrm{K}}$ must contain V as a rational factor. Further, the said norm N being

$$\begin{aligned}&(\sqrt{\mathrm{F}}+\sqrt{\mathrm{G}}+\sqrt{\mathrm{H}}+\sqrt{\mathrm{K}})\\ &\cdot(-\sqrt{\mathrm{F}}+\sqrt{\mathrm{G}}+\sqrt{\mathrm{H}}+\sqrt{\mathrm{K}})(\sqrt{\mathrm{F}}-\sqrt{\mathrm{G}}+\sqrt{\mathrm{H}}+\sqrt{\mathrm{K}})\\ &\qquad(\sqrt{\mathrm{F}}+\sqrt{\mathrm{G}}-\sqrt{\mathrm{H}}+\sqrt{\mathrm{K}})(\sqrt{\mathrm{F}}+\sqrt{\mathrm{G}}+\sqrt{\mathrm{H}}-\sqrt{\mathrm{K}})\\ &\cdot(-\sqrt{\mathrm{F}}-\sqrt{\mathrm{G}}+\sqrt{\mathrm{H}}+\sqrt{\mathrm{K}})(-\sqrt{\mathrm{F}}+\sqrt{\mathrm{G}}-\sqrt{\mathrm{H}}+\sqrt{\mathrm{K}})\\ &\qquad\qquad(-\sqrt{\mathrm{F}}+\sqrt{\mathrm{G}}+\sqrt{\mathrm{H}}-\sqrt{\mathrm{K}}),\end{aligned}$$

or

$$\Sigma\mathrm{F}^4-4\Sigma\mathrm{F}^3\mathrm{G}+6\Sigma\mathrm{F}^2\mathrm{G}^2+4\Sigma\mathrm{F}^2\mathrm{GH}-40\mathrm{FGHK},$$

where

$$\begin{aligned}16\mathrm{F}&=2a^2h^2+2h^2g^2+2g^2a^2-a^4-h^4-g^4,\\ 16\mathrm{G}&=2b^2f^2+2f^2h^2+2h^2b^2-b^4-f^4-h^4,\\ 16\mathrm{H}&=2c^2g^2+2g^2f^2+2f^2c^2-c^4-g^4-f^4,\\ 16\mathrm{K}&=2b^2c^2+2c^2a^2+2a^2b^2-a^4-b^4-c^4;\end{aligned}$$

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* Sylvester, J. J., "On the Relation between the Volume of a Tetrahedron. . . ."—*Cambridge and Dub. Math. Journ.*, viii., pp. 171–178; or *Collected Math. Papers*, i., pp. 404–410.

and 288 V^2 being

$$\begin{vmatrix} \cdot & a^2 & b^2 & h^2 & 1 \\ a^2 & \cdot & c^2 & g^2 & 1 \\ b^2 & c^2 & \cdot & f^2 & 1 \\ h^2 & g^2 & f^2 & \cdot & 1 \\ 1 & 1 & 1 & 1 & \cdot \end{vmatrix}, \quad \text{or W say,}$$

he succeeds, by skilful consideration of special cases, in determining the lengthy expression (72 terms) which is the quotient of N by W.

In 1859 Cayley * drew attention to Sylvester's very curious result, but made no advance in elucidation of it.

The object of the present paper is to show how the subject may be viewed altogether apart from geometry, and to open the way towards a complete understanding of it.

2. Taking any vanishing axisymmetric determinant

$$\begin{vmatrix} (11) & (12) & \dots & (1n) \\ (12) & (22) & \dots & (2n) \\ \dots & \dots & \dots & \dots \\ (1n) & (2n) & \dots & (nn) \end{vmatrix}, \quad \text{or } \Delta \text{ say,}$$

and writing its adjugate in the form

$$\begin{vmatrix} [11] & [12] & \dots & [1n] \\ [12] & [22] & \dots & [2n] \\ \dots & \dots & \dots & \dots \\ [1n] & [2n] & \dots & [nn] \end{vmatrix},$$

we see that since the two-line minors of the latter contain Δ as a factor we have

$$\begin{aligned} [11]\,[22] &= [12]^2, \\ [11]\,[33] &= [13]^2, \\ &\dots\dots \\ [11]\,[nn] &= [1n]^2. \end{aligned}$$

To these we may prefix for completeness' sake the truism $[11][11] = [11]^2$, and thus have

$$\frac{1}{\sqrt{[11]}} = \frac{\sqrt{[11]}}{[11]} = \frac{\sqrt{[22]}}{[12]} = \frac{\sqrt{[33]}}{[13]} = \dots = \frac{\sqrt{[nn]}}{[1n]}.$$

Consequently, since

$$\Delta = (11)[11] + (12)[12] + \dots + (1n)[1n],$$

or

$$= (12)[12] + (22)[22] + \dots + (2n)[2n],$$

or

$$= \dots\dots$$

---

* CAYLEY, A., "Note on the Value of certain Determinants, . . ."—*Quart. Journ. of Math.*, iii., pp. 275–277; or *Collected Math. Papers*, iv., pp. 460–462.

it follows that

$$\Delta = \left\{(11)\sqrt{[11]} + (12)\sqrt{[22]} + \ldots + (1n)\sqrt{[nn]}\right\} . \sqrt{[11]},$$
$$= \ldots\ldots\ldots\ldots$$

and therefore that

$$(11)\sqrt{[11]} + (12)\sqrt{[22]} + \ldots + (1n)\sqrt{[nn]} = 0,$$

it being impossible that the vanishing of Δ could necessitate the vanishing of [11]. We thus reach the following general theorem: *If* [rr] *be the cofactor of the element* (rr) *in an axisymmetric determinant* Δ *of the* nth *order, then the norm of*

$$(\sqrt{[11]}, \sqrt{[22]}, \ldots, \sqrt{[nn]})(\text{any row of } \Delta)$$

is divisible by Δ. (I.)

Sylvester's result is the particular case of this where the diagonal elements of Δ are zeros, and the elements of the last row and of the last column are units.

3. In examining the character of the cofactor of Δ in the norm let us confine ourselves for the present to the cases where there are not more than three non-zero elements in the first row of Δ, and first let us see what happens when all the elements of the first row vanish except the last two. The norm then is

$$\mathrm{N}\left\{(1, n-1)\sqrt{[n-1, n-1]} + (1, n)\sqrt{[n, n]}\right\}$$

and therefore is

$$(1, n-1)^2[n-1, n-1] \quad - \quad (1, n)^2[n, n].$$

But *in any determinant which has* $(1, r)$ *and* $(r, 1)$ *equal to zero for all values of* r *except* $n-1$ *and* n, *the cofactor of* $(n-1, n-1)$ *is*

$$-(1, n)(n, 1) . |(2, 2)(3, 3) \ldots (n-2, n-2)|,$$

and the cofactor of (n, n) *is*

$$-(1, n-1)(n-1, 1) . |(2, 2)(3, 3) \ldots (n-2, n-2)|;$$

so that the ratio of the two cofactors is

$$(1, n)(n, 1) : (1, n-1)(n-1, 1). \qquad \text{(II.)}$$

This ratio in the case of an axisymmetric determinant is $(1, n)^2 : (1, n-1)^2$, which is the same as saying that the norm in question vanishes. We thus have the theorem: *In any axisymmetric determinant* Δ *which has* $(1, r)$ *equal to zero for all values of* r *except* $n-1$ *and* n, *the cofactor of* Δ *in the norm of*

$$(1, n-1)\sqrt{[n-1, n-1]} + (1, n)\sqrt{[n, n]}$$

is 0,—*in other words, the norm vanishes.* (III.)

4. If all the elements of the first row vanish except the first and last, the norm then is

$$(1, 1)^2[1, 1] - (1, n)^2[n, n],$$

which

$$= (1, 1)^2\left|(2, 2)(3, 3)\dots(n, n)\right| - (1, n)^2.(1, 1)\left|(2,2)(3, 3)\dots(n-1, n-1)\right|$$

$$= (1,1)\left\{(1,1)\left|(2,2)(3,3)\dots(n,n)\right| - (1,n)^2\left|(2,2)(3,3)\dots(n-1, n-1)\right|\right\}$$

$$= (1, 1)\,\Delta.$$

Hence *in any axisymmetric determinant* Δ *which has* $(1, r)$ *equal to zero for all values of* r *except* 1 *and* n *the cofactor of* Δ *in the norm of* $(1, 1)\sqrt{[1, 1]} + (1, n)\sqrt{[n, n]}$ *is the element* $(1, 1)$. (IV.)

5. Passing now to those cases in which Δ has three non-zero elements in the first row, we naturally begin by considering the case where

$$\Delta \equiv \begin{vmatrix} a & b & c \\ b & d & e \\ c & e & f \end{vmatrix}.$$

Here the fact already known from §2 that the norm of $a\sqrt{A} + b\sqrt{D} + c\sqrt{F}$—that is,

$$N\left(a\sqrt{df-e^2} + b\sqrt{af-c^2} + c\sqrt{ad-b^2}\right)$$

—is divisible by Δ is itself an aid in finding the cofactor. For Δ being altered and the norm not being altered by changing the sign of b or c or e or all of them, it follows that the norm must be divisible by

$$\begin{vmatrix} a & b & -c \\ b & d & e \\ -c & e & f \end{vmatrix}, \quad \text{or } \Delta' \text{ say.}$$

Since, however, the norm of $\sqrt{x} + \sqrt{y} + \sqrt{z}$ is of the second degree in x, y, z, our norm must be of the 8th degree in the elements of Δ:

consequently the whole of the cofactor has not been found. Trying a result of Cayley's, namely,

$$\mathrm{N}(\sqrt{x}+\sqrt{y}+\sqrt{z}) = \begin{vmatrix} \cdot & 1 & 1 & 1 \\ 1 & \cdot & z & y \\ 1 & z & \cdot & x \\ 1 & y & x & \cdot \end{vmatrix},$$

and bearing in mind that for this determinant we may substitute

$$\begin{vmatrix} \cdot & \rho & \sigma & \tau \\ \rho & \cdot & z\bar{\tau}^{1} & y\bar{\sigma}^{1} \\ \sigma & z\bar{\tau}^{1} & \cdot & x\bar{\rho}^{1} \\ \tau & y\bar{\sigma}^{1} & x\bar{\rho}^{1} & \cdot \end{vmatrix}$$

we have

$$\mathrm{N}(\sqrt{a^2\mathrm{A}}+\sqrt{b^2\mathrm{D}}+\sqrt{c^2\mathrm{F}}) = \begin{vmatrix} \cdot & a^2 & b^2 & c^2 \\ a^2 & \cdot & \mathrm{F} & \mathrm{D} \\ b^2 & \mathrm{F} & \cdot & \mathrm{A} \\ c^2 & \mathrm{D} & \mathrm{A} & \cdot \end{vmatrix}$$

$$= \begin{vmatrix} \cdot & a^2 & b^2 & c^2 \\ a^2 & \cdot & ad-b^2 & af-c^2 \\ b^2 & ad-b^2 & \cdot & df-e^2 \\ c^2 & af-c^2 & df-e^2 & \cdot \end{vmatrix} = \begin{vmatrix} \cdot & a^2 & b^2 & c^2 \\ a^2 & 2a^2 & ad & af \\ b^2 & ad & \cdot & \mathrm{A} \\ c^2 & af & \mathrm{A} & \cdot \end{vmatrix}$$

$$= a^2 \begin{vmatrix} \cdot & a & b^2 & c^2 \\ a & 2 & d & f \\ b^2 & d & \cdot & \mathrm{A} \\ c^2 & f & \mathrm{A} & \cdot \end{vmatrix} = a^2 \begin{vmatrix} 2 & a & d & f \\ a & \cdot & b^2 & c^2 \\ d & b^2 & \cdot & \mathrm{A} \\ f & c^2 & \mathrm{A} & \cdot \end{vmatrix}.$$

It is thus seen that the missing cofactor is a^2, and that we have reached at one and the same time two theorems, namely, *In any three-line axisymmetric determinant* Δ *the cofactor of* Δ *in the norm of* $(11)\sqrt{[11]}+(12)\sqrt{[22]}+(13)\sqrt{[33]}$ *is*

$$(11)^2 \begin{vmatrix} (11) & (12) & -(13) \\ (12) & (22) & (23) \\ -(13) & (23) & (33) \end{vmatrix} \qquad \text{(V.)}$$

and

$$\begin{vmatrix} 2 & a & d & f \\ a & \cdot & b^2 & c^2 \\ d & b^2 & \cdot & \mathrm{A} \\ f & c^2 & \mathrm{A} & \cdot \end{vmatrix} = \begin{vmatrix} a & b & c \\ b & d & e \\ c & e & f \end{vmatrix} \cdot \begin{vmatrix} a & b & -c \\ b & d & e \\ -c & e & f \end{vmatrix} \qquad \text{(VI.)}$$

6. Since the right-hand member of (VI.) is not altered by performing the cyclical substitutions

$$\begin{pmatrix} a & d & f \\ d & f & a \end{pmatrix}, \quad \begin{pmatrix} e & c & b \\ c & b & e \end{pmatrix},$$

neither will the left-hand member. We thus have

$$\begin{vmatrix} 2 & a & d & f \\ a & . & b^2 & c^2 \\ d & b^2 & . & \mathrm{A} \\ f & c^2 & \mathrm{A} & . \end{vmatrix} = \begin{vmatrix} 2 & d & f & a \\ d & . & e^2 & b^2 \\ f & e^2 & . & \mathrm{D} \\ a & b^2 & \mathrm{D} & . \end{vmatrix} = \begin{vmatrix} 2 & f & a & d \\ f & . & c^2 & e^2 \\ a & c^2 & . & \mathrm{F} \\ d & e^2 & \mathrm{F} & . \end{vmatrix} \qquad \text{(VII.)}$$

This result could also have been got by considering the remaining norms

$$\mathrm{N}(\sqrt{\mathrm{A}}, \sqrt{\mathrm{D}}, \sqrt{\mathrm{F}})(b, d, e)$$
$$\mathrm{N}(\sqrt{\mathrm{A}}, \sqrt{\mathrm{D}}, \sqrt{\mathrm{F}})(c, e, f)$$

—a fact which is only natural when we note that these expressions are obtained from the corresponding expression of §5 by performing on it the cyclical substitutions.

7. When zero elements exist in the first row beside the three non-zero elements a distinction is necessary, as in §§3, 4, between the case where the first place is filled by a zero element and the case where it is not so filled. The latter case being the more closely allied to that of §5 falls to be considered first.

For convenience in writing let us limit the number of the said zeros, Δ being

$$\begin{vmatrix} a & . & . & . & e & f \\ . & g & h & i & j & k \\ . & h & l & m & n & o \\ . & i & m & p & q & r \\ e & j & n & q & s & t \\ f & k & o & r & t & u \end{vmatrix}.$$

Then, as before, we have

$$\mathrm{N}(a\sqrt{\mathrm{A}} + e\sqrt{\mathrm{S}} + f\sqrt{\mathrm{U}}) = \begin{vmatrix} . & a^2 & e^2 & f^2 \\ a^2 & . & \mathrm{U} & \mathrm{S} \\ e^2 & \mathrm{U} & . & \mathrm{A} \\ f^2 & \mathrm{S} & \mathrm{A} & . \end{vmatrix}.$$

But if we use $\vdots\begin{matrix} r\,s\,\ldots \\ r'\,s'\,\ldots \end{matrix}\vdots$ to denote the minor of Δ got by deleting the rth, sth, ... rows and the r'th, s'th, ... columns, it is readily seen that

$$\mathrm{S} = a\,\vdots\begin{matrix} 15 \\ 15 \end{matrix}\vdots - f^2\,\vdots\begin{matrix} 156 \\ 156 \end{matrix}\vdots,$$

and

$$\mathrm{U} = a\,\vdots\begin{matrix} 16 \\ 16 \end{matrix}\vdots - e^2\,\vdots\begin{matrix} 156 \\ 156 \end{matrix}\vdots.$$

Consequently, by performing the operations

$$\text{row}_2 + \begin{array}{:c:}156\\156\end{array}\,\text{row}_1,\quad \text{col}_2 + \begin{array}{:c:}156\\156\end{array}\,\text{col}_1,$$
$$\text{row}_2 \div a,\quad \text{col}_2 \div a,$$

we obtain

$$\mathrm{N}(a\sqrt{\mathrm{A}} + e\sqrt{\mathrm{S}} + f\sqrt{\mathrm{U}}) = a^2 \cdot \begin{vmatrix} \cdot & a & e^2 & f^2 \\ a & 2\begin{array}{:c:}156\\156\end{array} & \begin{array}{:c:}15\\15\end{array} & \begin{array}{:c:}16\\16\end{array} \\ e^2 & \begin{array}{:c:}15\\15\end{array} & \cdot & \mathrm{A} \\ f^2 & \begin{array}{:c:}16\\16\end{array} & \mathrm{A} & \cdot \end{vmatrix}.$$

Further, having the knowledge from §2 that the four-line determinant here is divisible by Δ, and seeing that it would remain unaltered although the sign of f were changed, we conclude that it is also divisible by the determinant resulting from Δ by substituting $-f$ for f. We thus have the theorem: *If any axisymmetric determinant Δ which has $(1r)$ equal to zero for all values of r except* 1, $n-1$, n, *the cofactor of Δ in the norm of*

$$(1,1)\sqrt{[1,1]} + (1,n{-}1)\sqrt{[n{-}1,n{-}1]} + (1,n)\sqrt{[n,n]}$$

is $a^2\Delta'$, where Δ' is the determinant differing from Δ merely in the sign of $(1,n)$. (VIII.)

Also, *if Δ be any axisymmetric determinant which has* $(1,r)$ *equal to zero for all values of r except* 1, $n-1$, n, *and Δ' be the determinant differing from Δ merely in the sign of* $(1,n)$

$$\Delta\Delta' = \begin{vmatrix} 2\begin{array}{:c:}1,n,n{-}1\\1,n,n{-}1\end{array} & (1,1) & \begin{array}{:c:}1,n\\1,n\end{array} & \begin{array}{:c:}1,n{-}1\\1,n{-}1\end{array} \\ (1,1) & \cdot & (1,n{-}1)^2 & (1,n)^2 \\ \begin{array}{:c:}1,n\\1,n\end{array} & (1,n{-}1)^2 & \cdot & \begin{array}{:c:}1\\1\end{array} \\ \begin{array}{:c:}1,n{-}1\\1,n{-}1\end{array} & (1,n)^2 & \begin{array}{:c:}1\\1\end{array} & \cdot \end{vmatrix}. \qquad \text{(IX.)}$$

It would be interesting to see this last theorem proved directly, that is to say, to see the right-hand side evolved from the left-hand side by mere application of the elementary properties of determinants. In default of such a proof the theorem may be verified as follows, the return to the special Δ with which we started being made to save space in writing:—

$$\Delta = a\mathrm{A} - e^2\begin{array}{:c:}15\\15\end{array} - f^2\begin{array}{:c:}16\\16\end{array} + 2ef\begin{array}{:c:}15\\16\end{array},$$

$$\text{and}\quad \Delta' = a\mathrm{A} - e^2\begin{vmatrix}15\\15\end{vmatrix} - f^2\begin{vmatrix}16\\16\end{vmatrix} - 2ef\begin{vmatrix}15\\16\end{vmatrix};$$

$$\begin{aligned}\therefore\quad \Delta\Delta' &= \left\{ a\mathrm{A} - e^2\begin{vmatrix}15\\15\end{vmatrix} - f^2\begin{vmatrix}16\\16\end{vmatrix}\right\}^2 - 4e^2f^2\begin{vmatrix}15\\16\end{vmatrix}^2,\\ &= a^2\mathrm{A}^2 + e^4\begin{vmatrix}15\\15\end{vmatrix}^2 + f^4\begin{vmatrix}16\\16\end{vmatrix}^2 - 2a\mathrm{A}e^2\begin{vmatrix}15\\15\end{vmatrix} - 2a\mathrm{A}f^2\begin{vmatrix}16\\16\end{vmatrix}\\ &\qquad + 2e^2f^2\begin{vmatrix}15\\15\end{vmatrix}\cdot\begin{vmatrix}16\\16\end{vmatrix} - 4e^2f^2\begin{vmatrix}15\\16\end{vmatrix}^2.\end{aligned}$$

On the other hand, the determinant on the right side of (IX.), if we express it in a series of terms proceeding according to binary products of the elements of the first row and first column, is

$$\begin{aligned}4e^2f^2\mathrm{A}\begin{vmatrix}156\\156\end{vmatrix} &+ a^2\mathrm{A}^2 + \begin{vmatrix}16\\16\end{vmatrix}^2 f^4 + \begin{vmatrix}15\\15\end{vmatrix}^2 e^4\\ &- 2a\begin{vmatrix}16\\16\end{vmatrix}\mathrm{A}f^2 - 2a\begin{vmatrix}15\\15\end{vmatrix}\mathrm{A}e^2 - 2\begin{vmatrix}16\\16\end{vmatrix}\begin{vmatrix}15\\15\end{vmatrix}e^2f^2.\end{aligned}$$

Now these two expressions, having five terms in common, will manifestly be equal if we can show that

$$\mathrm{A}\begin{vmatrix}156\\156\end{vmatrix} = \begin{vmatrix}15\\15\end{vmatrix}\cdot\begin{vmatrix}16\\16\end{vmatrix} - \begin{vmatrix}15\\16\end{vmatrix}^2;$$

and this is unnecessary because of the well-known theorem regarding a minor of the adjugate.

8. Before proceeding farther it is necessary to recall the series of identities*

$$\begin{aligned}|a_{11}a_{22}\ldots a_{nn}| &= \begin{vmatrix} |a_{11}a_{22}| & |a_{11}a_{23}| & \ldots\ldots & |a_{11}a_{2n}| \\ |a_{11}a_{32}| & |a_{11}a_{33}| & \ldots\ldots & |a_{11}a_{3n}| \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ |a_{11}a_{n2}| & |a_{11}a_{n3}| & \ldots\ldots & |a_{11}a_{nn}| \end{vmatrix} \div |a_{11}|^{n-2},\\ &= \begin{vmatrix} |a_{11}a_{22}a_{33}| & |a_{11}a_{22}a_{34}| & \ldots\ldots & |a_{11}a_{22}a_{3n}| \\ |a_{11}a_{22}a_{43}| & |a_{11}a_{22}a_{44}| & \ldots\ldots & |a_{11}a_{22}a_{4n}| \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ |a_{11}a_{22}a_{n3}| & |a_{11}a_{22}a_{n4}| & \ldots\ldots & |a_{11}a_{22}a_{nn}| \end{vmatrix} \div |a_{11}a_{22}|^{n-3},\\ &= \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\end{aligned}$$

and to point out the effect of putting

$$0 = a_{nn} = \left.\begin{aligned}&a_{1n}\\ =\ &a_{n1}\end{aligned}\right\}\text{ in the first,}$$

$$0 = a_{nn} = \left.\begin{aligned}&a_{1n} = a_{2n}\\ =\ &a_{n1} = a_{n2}\end{aligned}\right\}\text{ in the second,}$$

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* *Trans. R. Soc., Edinburgh*, xxix., pp. 47–54.

and so on. In the first place all the elements of the last row and of the last column of each compound determinant become resolvable into two factors, one of which is the minor common to all the elements of the said determinant. The division indicated can thus in part be performed, namely, in the first identity we can divide by a_{11}^2, in the second by $|a_{11}a_{22}|^2$, and so on, with the result that the row and column in question become, as far as may be, a repetition of the corresponding row and column on the left-hand side. Thus, in the case where $n = 6$ we have

$$\begin{vmatrix} a_1 & a_2 & a_3 & a_4 & a_5 & \cdot \\ b_1 & b_2 & b_3 & b_4 & b_5 & b_6 \\ c_1 & c_2 & c_3 & c_4 & c_5 & c_6 \\ d_1 & d_2 & d_3 & d_4 & d_5 & d_6 \\ e_1 & e_2 & e_3 & e_4 & e_5 & e_6 \\ \cdot & f_2 & f_3 & f_4 & f_5 & \cdot \end{vmatrix} = \begin{vmatrix} |a_1b_2| & |a_1b_3| & |a_1b_4| & |a_1b_5| & b_6 \\ |a_1c_2| & |a_1c_3| & |a_1c_4| & |a_1c_5| & c_6 \\ |a_1d_2| & |a_1d_3| & |a_1d_4| & |a_1d_5| & d_6 \\ |a_1e_2| & |a_1e_3| & |a_1e_4| & |a_1e_5| & e_6 \\ f_2 & f_3 & f_4 & f_5 & \cdot \end{vmatrix} \div a_1^2,$$

$$\begin{vmatrix} a_1 & a_2 & a_3 & a_4 & a_5 & \cdot \\ b_1 & b_2 & b_3 & b_4 & b_5 & \cdot \\ c_1 & c_2 & c_3 & c_4 & c_5 & c_6 \\ d_1 & d_2 & d_3 & d_4 & d_5 & d_6 \\ e_1 & e_2 & e_3 & e_4 & e_5 & e_6 \\ \cdot & \cdot & f_3 & f_4 & f_5 & \cdot \end{vmatrix} = \begin{vmatrix} |a_1b_2c_3| & |a_1b_2c_4| & |a_1b_2c_5| & c_6 \\ |a_1b_2d_3| & |a_1b_2d_4| & |a_1b_2d_5| & d_6 \\ |a_1b_2e_3| & |a_1b_2e_4| & |a_1b_2e_5| & e_6 \\ f_3 & f_4 & f_5 & \cdot \end{vmatrix} \div |a_1b_2|,$$

$$\begin{vmatrix} a_1 & a_2 & a_3 & a_4 & a_5 & \cdot \\ b_1 & b_2 & b_3 & b_4 & b_5 & \cdot \\ c_1 & c_2 & c_3 & c_4 & c_5 & \cdot \\ d_1 & d_2 & d_3 & d_4 & d_5 & d_6 \\ e_1 & e_2 & e_3 & e_4 & e_5 & e_6 \\ \cdot & \cdot & \cdot & f_4 & f_5 & \cdot \end{vmatrix} = \begin{vmatrix} |a_1b_2c_3d_4| & |a_1b_2c_3d_5| & d_6 \\ |a_1b_2c_3e_4| & |a_1b_2c_3e_5| & e_6 \\ f_4 & f_5 & \cdot \end{vmatrix} \qquad \text{(X.)}$$

9. Let us consider now the case where none of the three non-zero elements is in the place 11, Δ being

$$\begin{vmatrix} \cdot & \cdot & \cdot & d & e & f \\ \cdot & g & h & i & j & k \\ \cdot & h & l & m & n & o \\ d & i & m & p & q & r \\ e & j & n & q & s & t \\ f & k & o & r & t & u \end{vmatrix}.$$

Here, as before, we have

$$\mathrm{N}(d\sqrt{\mathrm{P}} + e\sqrt{\mathrm{S}} + f\sqrt{\mathrm{U}}) = \begin{vmatrix} \cdot & d^2 & e^2 & f^2 \\ d^2 & \cdot & \mathrm{U} & \mathrm{S} \\ e^2 & \mathrm{U} & \cdot & \mathrm{P} \\ f^2 & \mathrm{S} & \mathrm{P} & \cdot \end{vmatrix}$$

where

$$\mathrm{U} = \begin{vmatrix} \cdot & \cdot & \cdot & d & e \\ \cdot & g & h & i & j \\ \cdot & h & l & m & n \\ d & i & m & p & q \\ e & j & n & q & s \end{vmatrix}$$

$$= -d^2\begin{array}{:c:}146\\146\end{array} - e^2\begin{array}{:c:}156\\156\end{array} + 2de\begin{array}{:c:}156\\146\end{array},$$

$$S = -d^2\begin{array}{:c:}145\\145\end{array} - f^2\begin{array}{:c:}156\\156\end{array} + 2df\begin{array}{:c:}146\\145\end{array},$$

$$P = -e^2\begin{array}{:c:}145\\145\end{array} - f^2\begin{array}{:c:}146\\146\end{array} + 2ef\begin{array}{:c:}146\\145\end{array}.$$

If, therefore, we perform on the determinant the operations

$$\text{row}_2 + \begin{array}{:c:}156\\156\end{array}\text{row}_1,\qquad \text{row}_3 + \begin{array}{:c:}146\\146\end{array}\text{row}_1,$$

$$\text{col}_2 + \begin{array}{:c:}156\\156\end{array}\text{col}_1,\qquad \text{col}_3 + \begin{array}{:c:}146\\146\end{array}\text{col}_1,$$

there is obtained

$$N = \begin{array}{cccc} \cdot & d^2 & e^2 & f^2 \\ d^2 & 2d^2\begin{array}{:c:}156\\156\end{array} & 2de\begin{array}{:c:}156\\146\end{array} & 2df\begin{array}{:c:}156\\145\end{array} \\ e^2 & 2de\begin{array}{:c:}156\\146\end{array} & 2e^2\begin{array}{:c:}146\\146\end{array} & 2ef\begin{array}{:c:}146\\145\end{array} \\ f^2 & 2df\begin{array}{:c:}156\\145\end{array} & 2ef\begin{array}{:c:}146\\145\end{array} & 2f^2\begin{array}{:c:}145\\145\end{array} \end{array},$$

$$= 4d^2e^2f^2 \begin{array}{cccc} \cdot & d & e & f \\ d & \begin{array}{:c:}156\\156\end{array} & \begin{array}{:c:}156\\146\end{array} & \begin{array}{:c:}156\\145\end{array} \\ e & \begin{array}{:c:}146\\156\end{array} & \begin{array}{:c:}146\\146\end{array} & \begin{array}{:c:}146\\145\end{array} \\ f & \begin{array}{:c:}145\\156\end{array} & \begin{array}{:c:}145\\146\end{array} & \begin{array}{:c:}145\\145\end{array} \end{array},$$

$$= 4d^2e^2f^2 . \begin{vmatrix} g & h \\ h & l \end{vmatrix} . \Delta \qquad \text{by §8.}$$

We thus have the theorem: *In any axisymmetric determinant* Δ *which has* $(1, r)$ *equal to zero for all values of* r *except* $n-2$, $n-1$, n, *the cofactor of* Δ *in the norm of*

$$(1, n-2)\sqrt{[n-2, n-2]} + (1, n-1)\sqrt{[n-1, n-1]} + (1, n)\sqrt{[n, n]}$$

is

$$4(1, n-2)^2(1, n-1)^2(1, n)^2 . \begin{vmatrix} 2 & 3 & \ldots & n-3 \\ 1 & 3 & \ldots & n-3 \end{vmatrix} \qquad \text{(XI.)}$$

where $\begin{vmatrix} 2 & 3 & \ldots & n-3 \\ 2 & 3 & \ldots & n-3 \end{vmatrix}$ *is the minor of* Δ *occupying the rows and columns whose numbers are* 2, 3, …, $n-3$.

10. It is easy to see from §3 why the norm in the preceding case should vanish when any one of the three elements $(1, n-2)$, $(1, n-1)$,

$(1, n)$ vanishes: why it should vanish when $\begin{vmatrix} 2 & 3 & \dots & n-3 \\ 2 & 3 & \dots & n-3 \end{vmatrix}$ vanishes is not so apparent, and the reason when found is of considerable interest.

As a preliminary let us consider an axisymmetric determinant of the form

$$\begin{vmatrix} \cdot & \cdot & \cdot & \cdot & b & c \\ \cdot & d & e & f & h & i \\ \cdot & e & j & k & m & n \\ \cdot & f & k & o & q & r \\ b & h & m & q & v & w \\ c & i & n & r & w & x \end{vmatrix}$$

on the supposition that the minor

$$\begin{vmatrix} d & e & f \\ e & j & k \\ f & k & o \end{vmatrix} = 0.$$

It is at once evident that the determinant is equal to

$$- b^2 \begin{vmatrix} d & e & f & i \\ e & j & k & n \\ f & k & o & r \\ i & n & r & x \end{vmatrix} + 2bc \begin{vmatrix} d & e & f & i \\ e & j & k & n \\ f & k & o & r \\ h & m & q & w \end{vmatrix} - c^2 \begin{vmatrix} d & e & f & h \\ e & j & k & m \\ f & k & o & q \\ h & m & q & v \end{vmatrix}$$

$$= - b^2 \xi + 2bc\eta - c^2\zeta, \text{ say,}$$

where ξ, η, ζ may be looked on as the principal minors corresponding to the elements v, w, x of

$$\begin{vmatrix} d & e & f & h & i \\ e & j & k & m & n \\ f & k & o & q & r \\ h & m & q & v & w \\ i & n & r & w & x \end{vmatrix},$$

and where therefore

$$\begin{vmatrix} \xi & \eta \\ \eta & \zeta \end{vmatrix} = \begin{vmatrix} d & e & f & h & i \\ e & j & k & m & n \\ f & k & o & q & r \\ h & m & q & v & w \\ i & n & r & w & x \end{vmatrix} \cdot \begin{vmatrix} d & e & f \\ e & j & k \\ f & k & o \end{vmatrix} = 0.$$

From this it follows that

$$- b^2\xi + 2bc\eta - c^2\zeta = - (b\xi^{\frac{1}{2}} - c\zeta^{\frac{1}{2}})^2;$$

so that we have the theorem: *Any axisymmetric determinant which has* $(1, r)$ *equal to* zero *for all values of* r *except* $n-1$ *and* n *is expressible as a square if the minor* $\begin{vmatrix} 2 & 3 & \dots & n-2 \\ 2 & 3 & \dots & n-2 \end{vmatrix}$ *vanishes.* (XII.)

11. In order to find the actual quadrate expression in (XII.) we note that ξ, ζ being both axisymmetric determinants with a vanishing principal minor are themselves expressible as squares, namely,

$$-\xi = \left\{ r\begin{vmatrix} d & e \\ e & j \end{vmatrix}^{\frac{1}{2}} - n\begin{vmatrix} d & f \\ f & o \end{vmatrix}^{\frac{1}{2}} + i\begin{vmatrix} j & k \\ k & o \end{vmatrix}^{\frac{1}{2}} \right\}^2,$$

$$-\zeta = \left\{ q\begin{vmatrix} d & e \\ e & j \end{vmatrix}^{\frac{1}{2}} - m\begin{vmatrix} d & f \\ f & o \end{vmatrix}^{\frac{1}{2}} + h\begin{vmatrix} j & k \\ k & o \end{vmatrix}^{\frac{1}{2}} \right\}^2.$$

We thus have the determinant with which we started, and which has been shown equal to $-(b\xi^{\frac{1}{2}} - c\zeta^{\frac{1}{2}})^2$,

$$= -\Big[b\sqrt{-1}\left\{ r\begin{vmatrix} d & e \\ e & j \end{vmatrix}^{\frac{1}{2}} - n\begin{vmatrix} d & f \\ f & o \end{vmatrix}^{\frac{1}{2}} + i\begin{vmatrix} j & k \\ k & o \end{vmatrix}^{\frac{1}{2}} \right\}$$

$$- c\sqrt{-1}\left\{ q\begin{vmatrix} d & e \\ e & j \end{vmatrix}^{\frac{1}{2}} - m\begin{vmatrix} d & f \\ f & o \end{vmatrix}^{\frac{1}{2}} + h\begin{vmatrix} j & k \\ k & o \end{vmatrix}^{\frac{1}{2}} \right\} \Big]^2,$$

$$= \left[\begin{vmatrix} b & c \\ q & r \end{vmatrix} \cdot \begin{vmatrix} d & e \\ e & j \end{vmatrix}^{\frac{1}{2}} - \begin{vmatrix} b & c \\ m & n \end{vmatrix} \cdot \begin{vmatrix} d & f \\ f & o \end{vmatrix}^{\frac{1}{2}} + \begin{vmatrix} b & c \\ h & i \end{vmatrix} \cdot \begin{vmatrix} j & k \\ k & o \end{vmatrix}^{\frac{1}{2}} \right]^2,$$

as required.

It may be noted that the form of the result suggests the following alternative proof: By performing the operations

$$c\ \text{row}_5 - b\ \text{row}_6, \qquad c\ \text{col}_5 - b\ \text{col}_6$$

we have the given determinant

$$= \begin{vmatrix} \cdot & \cdot & \cdot & \cdot & \cdot & c \\ \cdot & d & e & f & ch - bi & i \\ \cdot & e & j & k & cm - bn & n \\ \cdot & f & k & o & cq - br & r \\ \cdot & ch - bi & cm - bn & cq - br & c^2v - 2bcw + bx^2 & cw - bx \\ c & i & n & r & cw - bx & x \end{vmatrix} \div c^2,$$

$$= - \begin{vmatrix} d & e & f & ch - bi \\ e & j & k & cm - bn \\ f & k & o & cq - br \\ ch - bi & cm - bn & cq - br & c^2v - 2bcw + bx^2 \end{vmatrix},$$

$$= \left[(ch - bi)\begin{vmatrix} j & k \\ k & o \end{vmatrix}^{\frac{1}{2}} - (cm - bn)\begin{vmatrix} d & f \\ f & o \end{vmatrix}^{\frac{1}{2}} + (cq - br)\begin{vmatrix} d & e \\ e & j \end{vmatrix}^{\frac{1}{2}} \right]^2 \qquad \text{(XIII.)}$$

by the theorem just used in regard to ξ and ζ.

12. Returning now to the norm

$$\text{N}(a\sqrt{\text{S}} + b\sqrt{\text{V}} + c\sqrt{\text{X}})$$

connected with the determinant

$$\begin{vmatrix} \cdot & \cdot & \cdot & \cdot & a & b & c \\ \cdot & d & e & f & g & h & i \\ \cdot & e & j & k & l & m & n \\ \cdot & f & k & o & p & q & r \\ a & g & l & p & s & t & u \\ b & h & m & q & t & v & w \\ c & i & n & r & u & w & x \end{vmatrix},$$

let us see what happens when the minor $\begin{vmatrix} 2 & 3 & 4 \\ 2 & 3 & 4 \end{vmatrix}$ vanishes. From §10 we learn that on that supposition S, V, X are expressible as squares, and consequently can have their roots extracted. We thus have from §11

$$a\sqrt{\mathrm{S}} + b\sqrt{\mathrm{V}} + c\sqrt{\mathrm{X}}$$

$$\begin{aligned} = \quad & a\left\{ \begin{vmatrix} b & c \\ q & r \end{vmatrix} \cdot \begin{vmatrix} d & e \\ e & j \end{vmatrix}^{\frac12} - \begin{vmatrix} b & c \\ m & n \end{vmatrix} \cdot \begin{vmatrix} d & f \\ f & o \end{vmatrix}^{\frac12} + \begin{vmatrix} b & c \\ h & i \end{vmatrix} \cdot \begin{vmatrix} d & k \\ k & o \end{vmatrix}^{\frac12} \right\} \\ & - b\left\{ \begin{vmatrix} a & c \\ p & r \end{vmatrix} \cdot \begin{vmatrix} d & e \\ e & j \end{vmatrix}^{\frac12} - \begin{vmatrix} a & c \\ l & n \end{vmatrix} \cdot \begin{vmatrix} d & f \\ f & o \end{vmatrix}^{\frac12} + \begin{vmatrix} a & c \\ g & i \end{vmatrix} \cdot \begin{vmatrix} d & k \\ k & o \end{vmatrix}^{\frac12} \right\} \\ & + c\left\{ \begin{vmatrix} a & b \\ p & q \end{vmatrix} \cdot \begin{vmatrix} d & e \\ e & j \end{vmatrix}^{\frac12} - \begin{vmatrix} a & b \\ l & m \end{vmatrix} \cdot \begin{vmatrix} d & f \\ f & o \end{vmatrix}^{\frac12} + \begin{vmatrix} a & b \\ g & h \end{vmatrix} \cdot \begin{vmatrix} d & k \\ k & o \end{vmatrix}^{\frac12} \right\}, \\ = \; & \begin{vmatrix} a & b & c \\ a & b & c \\ p & q & r \end{vmatrix} \cdot \begin{vmatrix} d & e \\ e & j \end{vmatrix}^{\frac12} - \begin{vmatrix} a & b & c \\ a & b & c \\ l & m & n \end{vmatrix} \cdot \begin{vmatrix} d & f \\ f & o \end{vmatrix}^{\frac12} + \begin{vmatrix} a & b & c \\ a & b & c \\ g & h & i \end{vmatrix} \cdot \begin{vmatrix} d & k \\ k & o \end{vmatrix}^{\frac12}, \\ = \; & 0. \end{aligned}$$

And this vanishing expression being one of the eight whose product constitutes the norm, the norm itself must vanish.

CAPETOWN, S.A.
Dec. 22, 1906.

EXAMINATION OF THE VALIDITY OF AN APPROXIMATE SOLUTION OF A CERTAIN VELOCITY EQUATION.

By A. Brown, M.A., B.Sc.

(Read November 28, 1907.)

§1. This problem has been suggested by the important part played by "initial conditions" in the solution of differential equations occurring in Dynamics. In certain cases the special character of the "initial conditions" makes a simple treatment of the equation possible; but sufficient attention has not been paid to the question whether the simplification introduced is legitimate, or to the investigation of the limits within which it holds.

To make the matter clearer, consider the equation—

$$\frac{dy}{dt} = -y + ky^2,$$

with initial condition $y = \lambda$ when $t = 0$, λ being supposed small.

One method of obtaining an approximate solution is to start with—

$$\frac{dy}{dt} = -y$$

and find the solution of this equation. The result is $\lambda\epsilon^{-t}$.

It is then assumed that if the solution thus obtained is small for all values of t, the result given is an approximate solution of the original equation.

The actual solution of the equation is $\lambda \, . \, \epsilon^{-t} \, . \, \frac{1}{1 - \lambda k(1 - \epsilon^{-t})}$, and in order that this be expansible in powers of λ for all values of t it is necessary that $\lambda k < 1$. If $\lambda k > 1$ the solution of the simplified equation is not even approximately a solution of the original equation; and unless λk is a small fraction the solution given will not be a good approximation. The validity of the simplification depends on the nature of the coefficients as well as on the smallness of λ; and it seems important to investigate how small λ must be for the simplified form to be used.

§2. The first question we consider is—
Under what conditions can a solution of—

$$\frac{dy}{dt}=a_1y+a_2y^2 \dots\dots\dots\dots (1)$$

with initial condition $y=\lambda$ when $t=0$, be obtained in a series of ascending powers of λ?

[This simple form is taken in order to illustrate the method used in the more general case, and also because the result can be tested by comparison with the solution in finite terms.]

To determine the possibility assume a solution of the form—

$$y=\mathrm{T}_0+\lambda\mathrm{T}_1+\lambda^2\mathrm{T}_2+ \dots\dots\dots\dots (2)$$

and determine the T's so as to satisfy the differential equation. If the series thus obtained is convergent the existence of a solution of this form is established.

From the initial conditions we have—

$$\mathrm{T}_0=0,\ \mathrm{T}_1=1,\ \mathrm{T}_2=0,\ \mathrm{T}_3=0,\ \dots \text{ when } t=0.$$

Substitute from (2) in (1)—

$$\therefore\ \mathrm{T}'_0+\lambda\mathrm{T}'_1+\lambda^2\mathrm{T}'_2+\dots=a_1(\mathrm{T}_0+\lambda\mathrm{T}_1+\lambda^2\mathrm{T}_2+\dots)$$
$$+a_2(\mathrm{T}_0+\lambda\mathrm{T}_1+\lambda^2\mathrm{T}_2\dots)^2,$$

$$\text{where } \mathrm{T}'_r \text{ means } \frac{d\mathrm{T}^r}{dt}.$$

Equating powers of λ—

$$\left.\begin{array}{l}\mathrm{T}'_0=a_1\mathrm{T}_0+a_2\mathrm{T}_0^2\\ \mathrm{T}'_1=a_1\mathrm{T}_1+a_2\,.\,2\mathrm{T}_0\mathrm{T}_1\\ \mathrm{T}'_2=a_1\mathrm{T}_2+a_2(\mathrm{T}_1^2+\mathrm{T}_0\,.\,\mathrm{T}_2)\\ \qquad\&c.\end{array}\right\} \dots\dots\dots\dots (3)$$

The first of these has the initial condition $\mathrm{T}_0=0$ when $t=0$; hence initially $\mathrm{T}'_0=0$; and thus $\mathrm{T}_0=0$ for all time.

Transform the set (3) by the substitution—

$$\mathrm{T}_r=\mathrm{S}_r\,.\,\epsilon^{a_1t} \dots\dots\dots\dots (4)$$

and the equations (3) become a set of which a typical member is—

$$\mathrm{S}'_r=a_2\,.\,\epsilon^{a_1t}[\mathrm{S}_0\mathrm{S}_n+\mathrm{S}_1\mathrm{S}_{r-1}+\dots+\mathrm{S}_{r-1}\,.\,\mathrm{S}_1+\mathrm{S}_r\mathrm{S}_0] \quad \dots\dots\dots (5)$$

The initial condition applicable to T_1 gives us $\mathrm{S}_1=1$ when $t=0$.

Further substitute—

$$\mathrm{S}_r=a_2^{r-1}\mathrm{R}_r \dots\dots\dots\dots (6)$$

for values of r above unity and the typical number (4) becomes—

$$R'_r = \epsilon^{a_1 t}[R_0R_r + R_1R_{r-1} \ldots + R_{r-1}R_0] \quad \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

Hence, using the initial conditions—

$$R_r = \int_0^t \epsilon^{a_1 t}[R_0R_r + R_1R_{r-1} \ldots + R_{r-1}R_1 + R_rR_0]dt \quad \ldots\ldots\ldots(8)$$

It is here to be noted that $R_0 = 0$; and hence when the expansion (2) is applicable the values of the coefficients can be determined by quadratures from (8).

The solution is—

$$\lambda\epsilon^{a_1 t}[1 + a_2\lambda R_2 + a_2^2\lambda^2 R_3 + \ldots] \ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

To discuss the convergence of (9).

From the values of R_0 and R_1, and the mode of formation of the subsequent coefficients, it is clear that the R's are all positive for positive values of t.

$\epsilon^{a_1 t}$ is one factor in the solution, and will occur to higher powers in the other factor; so that, if we include in our consideration large values of t, a necessary condition for the convergence of the series is a_1 negative.

Put $a_1 = -\alpha_1$ where α_1 is positive.

Applying this result we have—

$$\left.\begin{aligned}
&R_0 = 0\\
&R_1 = 1\\
&R_2 = \int_0^t \epsilon^{a_1 t}\,.\,R_1\,.\,R_1 < \frac{1}{\alpha_1}\\
&R_3 = \int_0^t \epsilon^{a_1 t}(R_1R_2 + R_2R_1) < \frac{1}{\alpha_1}(K_2K_1 + K_1K_2)\\
&\quad\vdots\\
&R_n < \frac{1}{\alpha}\left\{K_{n-1}K_1 + K_{n-2}K_2 \ldots + K_2\,.\,K_{n-2} + K_1K_{n-1}\right\}
\end{aligned}\right\} \ldots\ldots(10)$$

where the K's satisfy the relations—

$$\left.\begin{aligned}
&K_0 = 0\\
&K_1 = 1\\
&K_2 = \frac{1}{\alpha_1}\\
&K_3 = \frac{1}{\alpha_1}(K_2K_1 + K_1K_2)\\
&K_r = \frac{1}{\alpha_1}(K_{r-1}K_1 + K_{r-2}K_2 \ldots + K_2K_{r-2} + K_1K_{r-1})
\end{aligned}\right\} \ldots\ldots\ldots(11)$$

This can be simplified still further by putting—

$$\mathrm{K}_r = \frac{\mathrm{L}_r}{a_1^{r-1}} \text{ (excluding } r=0.$$

We now have—

$$\left.\begin{aligned} &\mathrm{L}_0 = 0 \\ &\mathrm{L}_1 = 1 \\ &\mathrm{L}_2 = 1 \\ &\mathrm{L}_3 = (\mathrm{L}_2\mathrm{L}_1 + \mathrm{L}_1\mathrm{L}_2) \\ \\ &\mathrm{L}_n = (\mathrm{L}_{n-1}\mathrm{L}_1 + \mathrm{L}_{n-2}\mathrm{L}_2 \ldots + \mathrm{L}_2\mathrm{L}_{n-2} + \mathrm{L}_1\mathrm{L}_{n-1}) \end{aligned}\right\} \cdots\cdots\cdots\cdots$$

To determine the L's put—

$$z = \mathrm{L}_2 + \mathrm{L}_3 x + \mathrm{L}_4 x^2 + \ldots$$

so that $1 + xz = \mathrm{L} + \mathrm{L}_2 x + \mathrm{L}_3 x^2 + \ldots$

$$\begin{aligned} x^2(1+x^2)^2 &= (\mathrm{L}_0 + \mathrm{L}_1 x + \mathrm{L}_2 x^2 \ldots)^2 \\ &= \mathrm{L}_0^2 + x(\mathrm{L}_0\mathrm{L}_1 + \mathrm{L}_1\mathrm{L}_0) + x^2(\mathrm{L}_0\mathrm{L}_2 + \mathrm{L}_1\mathrm{L}_1 + \mathrm{L}_2\mathrm{L}_0) + \ldots \\ &= \mathrm{L}_2 x^2 + \mathrm{L}_3 x^3 + \mathrm{L}_3 x^4 \\ &= x^2 z \\ &\therefore\ (1+x^2)^2 = {}^2 \\ &\therefore\ z^2x^2 + {}^2(2x-1) + 1 = 0 \\ &\therefore\ z = \frac{1 - x2 - \sqrt{1-4x}}{2x^2}\text{, selecting the appropriate sign} \\ &\qquad = \frac{1}{2}c_2 + \frac{1}{2}c_3 \,.\, x + \frac{1}{2} \,.\, c_4 x^2 + \ldots \end{aligned}$$

where c_r is the coefficient of $-x^r$ in the expansion of $(1-4x)^{\frac{1}{2}}$.

Hence $\mathrm{L}_r = \frac{1}{2}c_r$.

Now the expansion of $(1-4x)^{\frac{1}{2}}$ in ascending powers of x is convergent if $x < \frac{1}{4}$; hence $\mathop{\mathrm{L}}_{n=\infty} \frac{c_{n+1}}{c_n} \ngtr 4$, and $\therefore \mathop{\mathrm{L}}_{n=\infty} \frac{\mathrm{L}_{n+1}}{\mathrm{L}_n} \ngtr 4$.

Thus the solution of the differential equation is—

$$\lambda\epsilon^{-a_1 t}\left[1 + \frac{a_2\lambda}{a_1} \cdot \mathrm{H}_2 + \frac{a_2^2\lambda^2}{a_1^2}\mathrm{H}_3 \ldots\right]$$

where $\mathrm{L}\frac{\mathrm{H}_{n+1}}{\mathrm{H}_n} \ngtr 4$.

This will therefore be convergent if $\left|\frac{a_2\lambda}{a_1}\right| < \frac{1}{4}$.

Hence conditions which are certainly sufficient for the applicability of this form are—

$$(1)\ a_1 \text{ negative.}$$

$$(2)\ \lambda < \left|\frac{a_1}{4a_2}\right|.$$

(For the case considered in §1 this gives $\lambda < \frac{1}{4k}$, whereas we know that the range of availability of the method is bounded by $\lambda < \frac{1}{k}$).

§3. Apply the same method to the more general equation—

$$\frac{dy}{dt} = a_1 y + a_2 y^2 + a_3 y^3 + \quad \ldots\ldots\ldots\ldots\ldots\ldots(13)$$

subject to the initial condition $y = \lambda$ when $t = 0$.

Try a solution of the form—

$$y = T_o + \lambda T_1 + \lambda^2 T_2 + \ldots\ldots\ldots\ldots\ldots\ldots(14)$$

Substitute in (13) and equate coefficients of λ—

$$\left.\begin{aligned} \therefore T'_o &= a_1 T_o + a_2 T_o^2 + a_3 T_o^3 + \ldots \\ T'_1 &= a_1 T_1 + a_2(T_o T_1 + T_1 T_o) + a_3 \,.\, 3T_o^2 T_1 + \ldots \\ T'_1 &= a_1 T_2 + a_2(T_o T_2 + T_1^2) + a_3 \,.\, 3T_1^2 \,.\, T_o + \ldots \\ &\&\text{c.} \end{aligned}\right\}\ldots\ldots\ldots(15)$$

The initial conditions for the different T's are—

$$T_o = 0,\ T_1 = 1,\ T_2 = 0,\ T_3 = 0 \ \ldots \text{ when } t = 0.$$

Substitute $T_r = \epsilon^{a_1 t} S_r$—

$$\left.\begin{aligned} \therefore S_o &= 0 \\ S_1 &= 1 \\ S'_2 \epsilon^{a_1 t} &\,.\, a_2(S_o S_2 + S_1^2) + \epsilon^{2a_1 t} \,.\, a_3(3S_o S_1^2) + \ldots \\ S'_3 &= \epsilon^{a_1 t} \,.\, a_2(2S_1 S_2) + \epsilon^{2a_1 t}(3S_o S_3 + 6S_1 S_2 S_o) + \ldots \end{aligned}\right\}\ldots\ldots\ldots(16)$$

Once more it is to be noticed that the coefficients T or S can be immediately evaluated by quadratures, since the coefficient of T_r in the equation for T'_r is zero, and the earlier T's are calculated in succession.

As in the case discussed in §2, a first condition for convergence will be a_1 negative, equal to $-\alpha_1$ (say) where α_1 is positive. Follow the line taken in §2, putting $|a_2| = \alpha_2$, $|a_3| = \alpha_3$, &c.; we then find that each of the S's has, for all values of T, a modulus not greater than that of the corresponding R where the set of R's is given by the equations—

$$\left.\begin{aligned} &R_o = 0 \\ &R_1 = 1 \\ &R_2 = \frac{a_2}{a_1}(R_oR_2 + R_1^2) + \frac{a_3}{2a_1}(3R_oR_1^2) + \dots \\ &R_3 = \frac{a_2}{a_1} \cdot 2R_1R_2 + \frac{a_3}{2a_1}(3R_oR_3 + 6R_1R_2R_o) + \dots \\ &\qquad\qquad \&c \end{aligned}\right\} \dots\dots\dots\dots(17)$$

Write—

$$\eta = R_1\xi + R_2\xi^2 + R_3\xi^3 + \dots$$

Then $\frac{a_2}{a_1} \cdot \eta^2 + \frac{a_3}{2a_1} \cdot \eta^3 + \frac{a_4}{3a_1} \cdot \eta^4 + \dots$

$$\begin{aligned} &= \frac{a_2}{a_1}(R_1\xi + R_2\xi^2 + \dots)^2 + \frac{a_3}{2a_1}(R_1\xi + R_2\xi^2 + \dots)^3 + \dots \\ &= R_2\xi^2 + R_3\xi^3 + R_4\xi^4 + \dots \\ &= \eta - R_1\xi \\ &= \eta - \xi \end{aligned}$$

$$\therefore \xi = \eta - \frac{a_2}{a_1} \cdot \eta^2 - \frac{a_3}{2a_1} \cdot \eta^3 - \frac{a_4}{3a_1} \cdot \eta^4 \dots$$

The reversion of this series gives an expression for η in ascending powers of ξ, the coefficients therefore being the R's.

In a previous paper * I have shown that the reversed series is convergent if $|\xi| < J$, where $J = \sqrt{(1+2\beta)^2+1} \quad -(1+2\beta)$, β being the greatest of the set $\frac{a_2}{a_1}, \frac{a_3}{2a_1}, \frac{a_4}{3a_1} \dots$

Hence finally the solution of—

$$\frac{dy}{dt} = a_1y + a_2y^2 + a_3y^3 + \dots$$

with initial condition $y = \lambda$ when $t = 0$ can certainly be obtained by successive approximation in a convergent series of powers of λ provided

a_1 is negative,

and $|\lambda| < \sqrt{1+2\beta)^2+1} \quad -(1+2\beta),$

where β is the greatest of the set $\left|\frac{a_2}{a_1}\right|, \left|\frac{a_3}{2a_1}\right|, \left|\frac{a_4}{3a_1}\right| \dots$

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[*] Brit. Assoc. Report, 1905, p. 319.

NOTES ON THE MORPHOLOGY AND BIOLOGY OF *HYDNORA AFRICANA* Thunb.

By R. MARLOTH.

(Read November 28, 1907.)

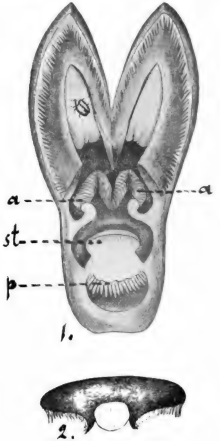
The genus *Hydnora*, which comprises several species (about seven), is confined to Africa, Bourbon, and Madagascar. They are all parasites, which grow on the roots of different shrubs and trees. The species which forms the subject of these notes, viz., *Hydnora africana*, uses the common milkbush of the karroo and karroid regions of the interior as its host, viz., *Euphorbia mauritanica* L.

The genus is usually placed in the natural order Rafflesiaceæ, which in its turn is sometimes combined with Cytinaceæ, as, *e.g.*, by Bentham-Hooker. It has been pointed out, however, by Solms-Laubach that the connection, as far as the morphological characters are concerned, is a very weak one, and that it would be better to establish Hydnoraceæ as a separate order. There is only one other plant nearly allied to *Hydnora*, viz., the South American genus *Prosopanche*, which is monotypic, possessing only one species, viz., *Prosopanche Burmeisteri* De Bary. This plant represents one of the few threads which connect the flora of South America with that of South Africa.

There are three species of *Hydnora* known from South Africa, but one only, viz., *H. africana*, is of fairly common occurrence.

The plant consists of an underground angular stem, which is covered with tubercles, but produces no roots, attaching itself to the roots of the host by sending suckers into its tissue. At these spots the Euphorbia root swells considerably, and as the free end usually dies, such a root does not feed its own plant any more, but serves merely as a feeding-tube of the parasite, through which the building materials which it requires are drawn from the host.

When the stem of the parasite, which creeps horizontally in the ground, has become sufficiently large and gorged with food materials, it produces buds, which soon appear above the surface of the ground, and finally open with three slits. It is in the structure of the flower that I have observed something which had hitherto escaped the attention of botanists.



HYDNORA AFRICANA Thunb.

1. Flower cut open, one-third removed.
   a, androecium.
   st, stigma.
   p, placentæ.
2. Transverse section through one perianth-lobe with the white body in the centre.

Each of the three segments of the perianth bears a large snow-white body on its inner side, while the remainder of the inner surface of the flower is of a bright fleshy colour. These three white bodies are not mentioned in any existing description of *Hydnora*, and I think I have found the reason why that is not the case.

When I made this little discovery by opening a large bud of the plant I was so surprised by the difference in appearance and structure that I analysed a portion of this body. While the entire plant is highly impregnated with tannin, containing almost as much as oak bark, this white substance is like a spongy pudding, not only in appearance but also in taste, containing fat and albuminous matter.

It occurred to me at the time that this might serve as an attraction to some animal, which in feeding upon these bodies would effect cross-pollination of the plant, but it was, of course, not possible to guess who the visitor might be. However, some friends of mine, among them Mr. Izaac Meiring at Worcester, sent me some more flowers, each one carefully wrapped up in a piece of cotton, and among them I found several which contained a number of black beetles. These have been identified by Mr. Péringuey as *Dermestes vulpinus*, an insect which is well known to collectors of skins and horns, as the beetle as well as the larva destroys animal specimens if not properly preserved.

As this beetle lives on carrion and other animal matter, it is evidently attracted by the smell of putrefaction which the white substance emits on decaying. The flower is really a trap for these beetles, for the inner side of each segment is lined with a fringe and covered with bristles which point inwards, allowing the beetles to creep in but preventing them from leaving the flower when their meal is finished. In their endeavour to escape they must necessarily crawl over the anthers and stigma, and consequently become covered with the pollen. When at last the flower withers and the bristles shrivel up, the beetles are able to escape and to enter another flower, thereby transporting the pollen from one flower to another and effecting cross-pollination.

As the anthers are situated above the stigma, self-fertilisation would also take place in case no crossing should have been effected.

These observations explain why the white bodies have not been described until now, for in the flowers which reached botanists at home these bodies had either been eaten out by insects or they had decayed during the drying of the juicy plant.

The question arises, which morphological part of the flower has been modified in such a remarkable way? This question I must leave undecided, for these bodies, which possess the function of nectaries, may be modified petals or staminodes or merely appendages of the perianth segments. It would be necessary to examine the other species of *Hydnora* in this respect, and it may be necessary to trace their evolution from the youngest stage.

It is often stated that the fruit of this plant, which contains a jelly-like mass, in which the tiny seeds are embedded, is a favourite food of the jackals, and the Colonial name, "jackals kost," has been given to it on that account. Whether that is correct or not I cannot say, but I have found many of the fruits scratched out of the ground in places where no jackals lived. It appears more likely that the unearthing of the fruits is done by the porcupines, for I have seen their burrows among the Euphorbia bushes where the *Hydnora* abounded. These animals would eat the contents, jelly and seeds, and in their nightly wanderings disseminate the plant afterwards.

The flowering season of the plant is spring, and the fruit ripens during the summer. If, however, no rains should have fallen at the proper time, the plant does not flower at all.

PROCEEDINGS
OF THE
SOUTH AFRICAN PHILOSOPHICAL SOCIETY.

ANNUAL ADDRESS TO THE MEMBERS
OF THE
SOUTH AFRICAN PHILOSOPHICAL SOCIETY
On the 8th of August, 1906.

By the President, J. C. BEATTIE, D.Sc.

ON SOME PHYSICAL PROBLEMS IN SOUTH AFRICA.

An address such as I propose to give you this evening requires in the first place a short introduction to avoid, amongst other things, a want of perspective. It is impossible in a short paper such as this is to take up every physical, much less every scientific, problem of interest to this country, and the choice of subject indicates only the speaker's limited knowledge; it does not mean that there are not other branches of knowledge of absorbing interest scientifically and economically, but rather that the predilection of the speaker is to those he is more or less acquainted with.

The title on the billet is too comprehensive even; a not too wide interpretation of it would bring in many problems in geology, and naturally any such address might be expected to take into account the problem of the standardisation of instruments in this country. At present there is no place in South Africa which does the work of a Reichsanstalt or a national physical laboratory. The consideration of this problem cannot be much longer deferred. It is, however, one which is South African only in so far as South Africa feels the needs of a modern civilisation. I hope at some later date to put before you further considerations on this matter of a South African Standards laboratory. The problems I wish to speak of to-night are more particularly connected with the physics of the earth's surface and atmosphere in South Africa.

The International Scientific Catalogue groups these subjects under the title Meteorology. This science in its narrower sense is more or less familiar to all of us, and I wish to direct your attention to it for a few minutes. The meteorologist must in the first instance be a good physicist. The world for him is a great physical laboratory in which the forces are mostly beyond his control. The principles, however, are throughout physical, and advance can only be made through a knowledge of, and the correct application of, them.

In considering meteorological data we may proceed in the following way. We consider at one place the change in any one element—such as the temperature—as time goes on. The first and natural period is the day. In a normal day the temperature varies in a manner which is so regular that the changes may be represented by fairly simple mathematical formulæ. There is for this and for each of the other meteorological elements a well-marked daily variation; the diagrams before you show this variation for Cape Town in temperature, humidity, and barometric pressure.

Instead of taking the day as our unit of time we can take the year. The phenomena looked at from this point of view show a second well-marked variation. This is the annual variation.

The second set of diagrams shows this again for Cape Town.

Still confining ourselves to the meteorological data at one place, we may now inquire whether there are other variations extending over longer or shorter periods, such as the so-called eleven-year period; and, finally, we may try to ascertain whether the data give any indication of a secular change. In other words, is it possible to decide whether Cape Town is becoming hotter or colder, drier or wetter. The immense practical value of this subject now becomes evident. With sufficient data it might be possible to say whether or not the average yearly rainfall at any given place was increasing or decreasing, and to determine whether the change—if any—is connected with any other change, such as an increase or decrease of vegetation in the neighbourhood of this place, and whether or not it would be possible by human agency to control the change.

I pass on to consider two subjects which in some of their manifestations are closely related to meteorology—the subjects of earth magnetism and of atmospheric electricity. A magnet suspended freely at its centre of gravity takes up at a given place, and at a given instant, a definite position depending on the earth's field at that place at that instant. If we consider the magnetic data for a given place, as time goes on we find well-marked daily and annual variations, just as in the case of the meteorological elements. These diagrams show this for Cape Town. Further study of the magnetic elements at one place shows, however, a new phenomenon. If we consider the declination, for example, we see that there is another and slow change going on. This is the secular variation, whose period would appear to be about a thousand years.

The study of atmospheric electricity may be approached from two sides. A charged insulated conductor, for example, will not—even if it is supported by a perfect insulator—retain its charge indefinitely; and the rate at which the charge is lost varies with time at the same place. The systematic study of this loss in a free atmosphere has only been carried on for a few years, but it is already evident that here also there is a daily and an annual period. You will see this very clearly in these diagrams, which give the result of observations by Mr. Lyle at Bloemfontein.

A second method of studying the electric state of the atmosphere is to observe the difference in electric intensity between a point at a fixed distance above the ground and the earth itself. In this case also daily and annual variations are well-established facts.

If instead of considering the change at one place as time goes on we consider the value of the elements at the same instant at every part of a given region, we would then have a survey of that region for meteorology, magnetism, or electricity, as the case may be.

The results of such surveys are embodied in maps. In a given region, for example, all places with the same temperature may be joined together by a line called an isotherm. A number of isotherms corresponds to a temperature contour. The particular isotherms which we obtain by taking the mean of the temperatures of a sufficient number of years, and which therefore does not show the effect of periods such as the daily or the annual, does not differ much, if at all, in position if it is derived from the mean of the temperatures of another sufficient number of years. In other words, there is no sign of a secular variation of temperature. It is impossible as yet to say whether this is due to insufficient and non-homogeneous data or to the fact that the region under consideration is actually not becoming slowly hotter or colder. A map of this nature for South Africa would show irregularities due to the relative position of sea and land and to the different heights of the latter if the effect of the height were not eliminated by a special calculation. Another way of showing the temperatures in a region is to calculate the average temperature along a line of latitude, and then to note on the map for each place the difference between the actual temperature of the place and the mean temperature of its latitude. Such a map shows what are called temperature anomalies.

In the case of a map showing the results of a magnetic survey the state of a region is shown by isomagnetic lines. The map before you shows the lines of true dip for South Africa for July 1, 1903.

The smaller maps show the dip in South Africa at other periods. These have been derived by calculation, and do not give the deviations due to local disturbances. The first thing that strikes one in comparing the different maps is the fact that there are great displacements of the isomagnetic lines from one period to another; secondly, the lines in the larger map are very tortuous in some regions, in others they are bunched together, and in others still they are spread widely. The consideration of the causes of these arrangements of the lines brings out one of the differences between earth magnetism and meteorology. The latter embraces results which arise from the effect of our sun on the land surface and its adjoining waters, and which is uninfluenced by the earth's crust below a depth of a few yards. On the other hand, earth magnetism gives us results which after the sun's effect—shown in the daily and annual variations—is eliminated, depend on the nature of the earth's crust to some distance below the surface. This effect is shown very clearly if we again present the results at different parts in the form of deviations from the mean magnetic state as derived from all the observations in the region. In such a map certain places have a greater dip than the mean; that is to say, these places are in South Africa magnetically equivalent to weak south poles, which pull down a freely suspended magnet more than the other parts of the region. When the observation of the other magnetic elements are treated in the same way it is then possible to determine the position of the disturbing body and its extent. In Sweden and in America surveys of this nature have been made to locate iron ore deposits.

Another physical experiment allows us to obtain information concerning the density of the material under the earth's surface. The attraction of the earth on a body is known to be different at different parts of the earth after the necessary allowance has been made for the shape of the earth. The gravitational irregularities in a particular region can be shown on a map representing the results of a gravitational survey of that region. The map might have on it isogravitational lines, or it may have marked on it the gravitational anomalies. The latter are present in the neighbourhood of mountains, and even in plains which on the surface give no indication of differences of constitution. A well-known example is that of Moscow, standing on a plain which underneath has a density much smaller than one would expect. The anomaly is due to the presence of a great coalfield.

I have now stated to you how the subjects of meteorology, earth magnetism, and gravitation are related to each other. You will now understand how it is that the study of meteorology is incomplete without a simultaneous study of the daily and annual variations of earth magnetism and of atmospheric electricity, and how the geologist's knowledge of the constitution of the earth's crust must be supplemented by a study of magnetic and of gravitational anomalies.

I come now more particularly to consider what we in South Africa have done for the study of these subjects, and whether what we have done is sufficient to give us all the information we desire. You will have noticed that the deductions from any survey can be drawn only after corrections have been applied to eliminate the effect of known causes such as the sun's heat and the shape of the earth, and in the case of earth magnetism allowance has been made for the secular variation. A lack of knowledge of these corrections would lead us to make wrong deductions, and the first essential is the establishment of a well equipped central station where continuous records of the phenomena may be taken. After that it would be necessary to establish one or two subsidiary stations for usually a short period to take continuous records at other properly chosen places. It would then be possible to make surveys of the country and correct the results for the deviations I have spoken of.

At present there is a station in the Transvaal purely meteorological. De Beers have at Kimberley a meteorological station whence Mr. Sutton has issued a number of papers which constitute a most valuable contribution to South African Meteorology.

The Imperial Government had a very complete station at the Royal Observatory in which meteorological and magnetical observations were taken for a number of years between 1840 and 1850. What knowledge we have of the daily and the annual variations of the meteorological and the magnetic elements for this part of the Colony is derived from observations taken there.

The Cape Colony has never supported such a station, which is a matter for wonder, because science is seldom received unsympathetically, unless the financial state is bad, and since the demise of the Imperial Government's station there have been several occasions on which the Government had money to spend. Again, Cape Colony is essentially an agricultural country, and the study of meteorology has for the agriculturist immense economic importance.

The Imperial Government has been often urged to re-establish its station at the Cape; such an event is now impossible. The advent of the electric tram has made the Royal Observatory an unsuitable place for such work; and it is scarcely dignified on our part to approach the Home Authorities on such a local matter, when we have done nothing ourselves.

Perhaps I may be permitted to give a short account of the attempts which have been made to get the Imperial Government to reopen its station here.

The British Association in 1887 reported "that the establishment of regular magnetic observatories at the Cape of Good Hope and in South America would materially contribute to our knowledge of earth magnetism."

Again in 1889 the British Association reported that it was "more than ever of the opinion expressed in 1887."

In 1891 the British Association reported that, thanks to Sir David Gill's offer of hearty co-operation in the matter, it was of opinion that at last the station was to be re-established; unfortunately the negotiations fell through.

In 1898 the International Meteorological Commission approached this time the Government of Cape Colony on the matter through the president of the British Association. The Government of the day expressed their sympathy, but said the time was unsuitable for taking action.

I may mention that the appeal to South America resulted in the establishment of three stations by the Argentine.

Still another attempt has been made to persuade the Colonial Government to found such a station. The need is greater to-day than ever it was; and in 1904 a scheme was prepared and submitted to the Government and received sympathetically by them. The opinion of those of the leading magneticians of the world who were consulted was entirely in favour of it, Dr. L. A. Bauer, of Washington, U.S.A., says in a letter on the matter:—

"In setting forth the importance of a magnetic survey and of magnetic observatories in South Africa, it will not be amiss to call attention to the plans—partly in preparation and partly in execution—for accomplishing a general magnetic survey of the greater portion of the globe within a period of about fifteen or twenty years. This will necessarily demand the active co-operation of all civilised countries, and will make absolutely necessary the establishment of magnetic observatories in well-placed localities such as yours."

Dr. A. Schmidt, of Potsdam, says :—

"I have insisted for some time now on the necessity for the establishment of a magnetic station at the Cape, and I propose to address the International Magnetic Congress, which meets in Innsbruck this year (1905), on a scheme of my own in which, among other things, I point out the necessity of such a station in Cape Colony."

In another part of his letter Dr. Schmidt expresses his surprise that Cape Colony has not at least one first-class meteorological station. "Every European state—even the smallest and the poorest—has such stations, and everywhere the importance of a good meteorological station is recognised."

It would only weary you were I to read what men like Lord Kelvin, Sir Arthur Rücker, Monsieur Mascart, Professor Schuster and Captain Creak have said, all to the same effect.

Although this Colony lacks a properly equipped station such as other civilised states have, yet a great amount of valuable work has been done. I had intended to give a summary of this, but that would carry me too far and try too much your patience. I hope that some day a South African meteorologist will take up the story of the work in that subject, which has been carried out by observers in South Africa. I myself can to-night only give you a rough outline of what has been done in the other three subjects I have mentioned. Unfortunately in gravitation and in atmospheric electricity the record is very short. So far as I know gravitational observations have been made only at the Royal Observatory; there has been no attempt at a gravitational survey. A surface survey would give us much valuable information; and in Johannesburg and Kimberley it could be supplemented by observations at considerable depth below the surface.

In atmospheric electricity I know of no observations other than a set taken by Mr. Lyle at the Grey College, Bloemfontein, and another set taken by Mr. Logemann at the South African College in Capetown.

The work in earth magnetism began as long ago as 1595. In that year the declination was observed at Mossel Bay by Houtman while on a voyage to the East Indies. From that date to the present time observations have been made at irregular intervals at different points on the coast from Saldanha Bay to Delagoa Bay. Observations have also been made by surveyors in different parts of the interior. Mr. J. J. Bosman has been good enough to supply me with a list of these; and the three diagrams you see here represent the magnetic state of the country at three different epochs, as derived from these observations.

Mr. Bosman has himself made a number of observations in different parts of South Africa, chiefly in Bechuanaland, and Mr. Fourcade has made observations in the Knysna.

I have already referred to the work carried out at the Royal Observatory between 1840 and 1850. This work was continued by Sir Thomas Maclear and Mr. Stone. It came to an end in 1869.

Finally, during the last eight or nine years a first magnetic survey of Cape Colony, Natal, the Transvaal, the Orange River Colony, and parts of Rhodesia has been made. The Portuguese authorities of Mozambique have also made a beginning with a similar survey in Portuguese East Africa.

In conclusion, I hope that you agree with me that there are many physical problems in South Africa awaiting solution, and that you are convinced with me of the necessity for a permanent physical observatory, from which the work may be directed, and in which the observations for the proper correction of survey results may be made. It has too long been a reproach to South Africa that the thorough study of such problems has been neglected. As many of you are doubtless aware, we hope soon to obtain a Charter; should these hopes be realised, the Society will only be following in the footsteps of its model if it takes up the problems I have spoken of to-night.

ORDINARY MONTHLY MEETING.

October 28, 1905.

Dr. J. C. **Beattie**, President, in the Chair.

The following nominations were made: Mr. H. **Kynaston**, Transvaal Geological Survey, by A. W. **Rogers** and L. **Péringuey**; Professor R. B. **Young**, by A. **Young** and L. **Péringuey**.

Messrs. A. L. **Hall** and T. **Loveday** were elected Ordinary Members of the Society.

Mr. L. **Péringuey** exhibited some stone implements and read the following note:—

While boring for water in the Darling District, Mr. H. M. Oakley discovered in a sand drift blown away by the wind, what appeared to him to be fossilified bones of mammals. Mr. Martin Versfeld, the owner of the farm, informed him that while busy planting some grass to fix the sand he had unearthed what he thought was the skull of a very large ox. This remnant Mr. Oakley at once recognised as being similar to the one exhibited in the South African Museum, and described by Seeley under the name of *Bubalus baini*. Not only did Mr. Oakley communicate at once this discovery to the Museum authorities, but he also was instrumental in having this most interesting relic of the Tertiary times presented to the Institution by its owner, Mr. Martin Versfeld, of Slangkop.

Encouraged by his find, Mr. Oakley pursued further investigations and discovered in the immediate vicinity of where the first remains were found a considerable quantity of other mammalian relics, among which may be noted the upper jaw of a probably new horse, a variety, if not a new species, of Rhinoceros, &c. These remains are being investigated by our colleague, Dr. R. Broom, and the geological foundation will be examined by Mr. A. W. Rogers, the head of the Geological Survey, as soon as he returns from up-country, at or about Christmas.

Interesting as Mr. Oakley's discovery is from a geological as well as a palæontological point of view, it is not less so from the antiquarian. Mr. Oakley found to his very great surprise that not only were some of the bones heaped up here and there, but also that they had been split for getting at the marrow, or pounded at one end when too large for being easily cleft, and he rightly came to the conclusion that this was evidence of man's agency. Availing myself of his guidance, I went to inspect the spot in company with Mr.

J. M. Bain, and we found the denuded part of the dune sprinkled here and there with a considerable number of minute stone implements, some of which I am exhibiting to-night. No large ones of the palæolithic type were met with. These liliputian implements (some of them are not more than 11 mm. long) must, I think, be taken to have been arrow-heads; the others are plainly knives, and to those who may doubt of their having been implements at all, I show similar knives used by a bushman to carve toy-like pieces of wood representing a gun and a spade, and found together in a kraantz in Sutherland among ashes and other *dèbris*. The cores from which these pygmy implements were made were also found *in sitû*. Small scrapers showing secondary chippings, and similar to those met lately in the Transvaal by our colleague, Mr. J. P. Johnson, were also found. But if we did not, to my disappointment, meet with large instruments of the type occurring so frequently in the Stellenbosch and Paarl Districts, we found the mullers, or beaters, with which the bones have been crushed. They are of the same form as those found in other middens.

The author of this note does not mean to imply that the makers of these pygmy implements were contemporaneous with *Bubalus baini*, because bones of other living animals like the eland, the sand-mole, &c., are also to be found in that deposit, but the discovery is sufficiently important to be brought to the notice of the Society.

Professor J. C. BEATTIE read a paper on "Atmospheric Electricity," by Messrs. J. C. BEATTIE and J. LYLE. The observations were carried out in 1902-3 by Mr. J. Lyle in Bloemfontein for a year, and by Mr. W. H. Logeman in Cape Town for part of a year. The intention was to find what relation, if any, existed between the observed values of the leak of electricity as measured by individual observations with an Elster Geitel electroscope and simultaneously observed values of barometric pressure, relative humidity, and temperature.

The observations show that there is a diminution of the leak of positive and of negative electricities with increasing relative humidity except when the relative humidity is between 40 and 50 per cent. Also in the morning, when the temperature is rising, and the relative humidity dropping the leak of negative electricity is greater than that of positive, whereas in the afternoons with the temperature falling and the relative humidity increasing, the negative leak is, as a rule, less.

The leak of electricity increases with increasing temperature and decreases with decreasing temperature, the maximum leak being a little earlier than the maximum temperature.

The relations between barometric pressure and leak is somewhat obscure in these observations, and the results do not give as yet a definite relationship between the two.

Daily observations have also been taken for one week in every three months.

A communication on the climate of East London, Cape Colony, by J. R. SUTTON, M.A., F.R.Met.S., was read.

This paper is a summary of the meteorological observations made at East London during the 21 years, 1884–1904, and a brief discussion comparing the results with those obtained at other stations in South Africa.

The annual variation of barometric pressure is of the same order as that found elsewhere in the country, *i.e.*, greatest in July and least in January, and the mean annual range is also about the same as it is at Durban and Kimberley. The mean pressure for the year is about 30·03 inches with a total known range of 29·3 inches to 30·7 inches.

The mean maximum and minimum temperatures are 72·2 degrees, and 57·5 degrees respectively. The highest temperature on record is 106 degrees (in April), the lowest 36 degrees (in July). February is the warmest month, July the coldest, but the days in September are colder than those in July and August, although the nights are warmer. On account of the hot winds frequent in the winter half of the year, the mean temperatures during the day are very little less in winter than they are in summer, but the winter nights are much colder than summer nights. Hot winds generally come with a low barometer from some inland direction, and are very dry. At East London they are confined almost entirely to the hours of daylight, and have no very great influence upon the nocturnal temperatures. They have also a semi-annual period, and very pronounced ones seldom occur either in summer or in June and July.

The monthly variation of cloud is similar to that of Kimberley; but the rain comes to its maximum intensity rather earlier. The clouds pass over East London chiefly from the south-west, at Kimberley chiefly from the west. Wind and clouds at East London during rain also come chiefly from south-west, and the author finds nothing in them to give any colour to the "south-easterly rain-bearing clouds" myth.

Emphasis is laid upon the interesting and important spell of low temperature and pressure characteristic of the middle of July, which occurs at East London, just as it probably does everywhere else in South Africa at the same time.

ORDINARY MONTHLY MEETING.

November 29, 1905.

Dr. J. C. BEATTIE in the Chair.

Messrs. H. KYNASTON and Professor R. B. YOUNG were elected Ordinary Members of the Society.

Mr. L. PÉRINGUEY exhibited some fragments of Strand Looper pottery, the rind of which bear a series of perforations; such a style of ornament was not known hitherto.

Mr. E. HUTCHINS read a paper on the "Cyclical year, 1905, and the coming season."

ORDINARY MONTHLY MEETING.

February 28, 1906.

Dr. J. C. BEATTIE, President, in the Chair.

Mr. W. A. CALDECOTT, Johannesburg, was nominated by W. L. SCLATER and L. PÉRINGUEY as Ordinary Member.

Mr. A. W. ROGERS exhibited rock specimens showing the occurrence of glacial beds in the Griqua Town series of Hay. Flattened and striated stones, whose peculiarities can at present only be attributed to glacial agencies, occur in hard, ferruginous rock near the top of the Griqua Town series in Hay. They are of various sizes, from an inch or two up to 18 inches long. They consist of chert; a few grit pebbles are found, but as yet no granites or other igneous rocks are known from those beds; some hollows, now partly filled with specular iron, may represent limestone fragments. The boulders are scattered at wide intervals through the matrix in most cases, though gravelly grits also occur.

The glacial beds have been found at widely separated places in Hay; along both the east and west sides of the Ongeluk syncline, near the Vlak Fontein syncline, the Lucas Dam syncline, and the Juanana syncline; in every case within 30 feet or so of the base of the volcanic rocks overlying the Griqua Town series.

Mr. A. L. DU TOIT read a paper on "Under Water in South-Eastern Bechuanaland." The term South-Eastern Bechuanaland is used as including the divisions of Mafeking and Vryburg as far westwards as Kuruman. The country is gently undulating and fairly well wooded, although there is little or no running water. Supplies are obtained chiefly from wells, sometimes from dams. Water percolates below the sand in the beds of the rivers, and can be recovered by making shallow pits.

Water accumulating in the soil tends to move towards lower levels and is influenced by topographical features, dykes, fissures, &c. Pans and patches of soil, covered by calcareous tufa, are first-rate places at which to sink wells. The underlying formation is important in connection with underground storage.

Granite and gneiss are uncertain rocks in which to sink, though sometimes they afford excellent supplies. The diabase comes next in water-bearing capacity, but the dolomite formation of the Kaap Plateau is certainly the finest water carrier.

Of the other factors upon which the accumulation of water depends, the most important is the rainfall. This varies from 15 to 26 inches, and takes place in the summer months; practically none of the water reaches the sea directly.

The proportion absorbed depends upon the porosity of the soil and the duration of the periods of rainfall; the losses are caused by evaporation from the surface and through capillary action, and owing to transpiration by plants.

In years of ordinary rainfall the additions to the soil must just balance the quantities lost, and it is only when the rainfall is abnormal that the level of the ground water is permanently raised. When artificial openings are made the soil experiences a certain loss which may not be made good afterwards, and the wells have to be deepened until they attain their limiting depth. Boreholes can be used to drain the greater depths, but no advantage will be gained by going down more than a few hundred feet.

There are no localities where large artesian supplies can be readily obtained. In some of the valleys subsurface dams can be adopted successfully. For ordinary requirements there is plenty of water at the present time, but care should be taken that too great a drain is not made upon the natural resources of the country.

A paper by Dr. THOS. MUIR, "A Set of Linear Equations connected with Homofocal Surfaces," was read.

ORDINARY MONTHLY MEETING.

March 28, 1906.

Dr. J. C. BEATTIE, President, in the Chair.

Mr. E. T. MELLOR was nominated as an Ordinary Member by Messrs. A. W. ROGERS and A. L. DU TOIT.

Mr. W. A. **Caldecott** was elected an Ordinary Member.

Professor H. H. W. **Pearson** gave a short account of the trend of modern morphological research on the surviving members of the ancient group, the Cycads. The relationship of the group to the *Pteridophyta* was discussed and microscopic slides showing (*a*) pollen tubes, (*b*) the ciliated spermatozooid, (*c*) the Karyokinesis of the nucleus of the central cell of the archegonium prior to the formation of the canal-cell nucleus, of *Encephalartos Alstensteinii* were exhibited. A specimen of *Stangeria paradoxa* with an apogeotropic root and a microscopic section showing the endophytic "Nostoc" were also shown. The specimens exhibited, and those from which the microscopic preparations were made were presented by Miss Alice Pegler, Miss A. W. Tucker, and Mr. J. Chalwin, to whom acknowledgments were expressed.

Mr. G. H. H. **Fincham** read a communication "On the Nature of Effect of the Sun-spot Frequency on the Variation of the Magnetic Elements at the Cape of Good Hope." By a consideration of Sabine's observations at the Cape of Good Hope obtained in 1842–46, it is shown that the sum of the sun-spot effect on the declination is a maximum in winter; the same result was found for the horizontal intensity.

ORDINARY MONTHLY MEETING.

April 25, 1906.

Dr. J. C. **Beattie**, President, in the Chair.

Mr. W. T. **Saxton**, Cape Town, was nominated as Ordinary Member by Professor H. W. W. **Pearson** and Dr. J. C. **Beattie**, and Messrs. W. A. **Humphrey**, Pretoria, E. **Jorissen** and G. **Sandberg**, Johannesburg, by Dr. S. L. **Corstorphine** and L. **Péringuey**.

Mr. E. T. **Mellor**, of Pretoria, was elected an Ordinary Member.

Mr. L. **Péringuey** read a paper "On the Round Perforated Stones (Tikoe), alleged to have been made by Bushmen for the purpose of giving weight to the 'Kibi' or Digging Stick." That some aborigines, Bushmen or Hottentots, made use of these stones for the aforesaid purpose was now proved. Although Kolben did mention the digging stick as a part of the Hottentot household utensils, he never said anything about the perforated stone being used. Sparrmann, however, does so. Then follows Burchell, who figures the Tikoe and the Kibi. Livingstone, in his last Journal, gives evidence on the subject, but quotes from memory. In the figures given by him the stone is a flat disk. That the stones were used for the alleged purpose by some aborigines is, however, made now clear by Bushman paintings, tracings of which were exhibited by permission of Professor Young, of Johannesburg. The aborigines are represented with the sticks and stones going a digging, both sexes being delineated. In other drawings some mythical figures were, however, using these stones as club-heads. The author contended that although put to that twofold purpose it did not follow that the stones had been perforated, in the manner they have, for these two special purposes. The great diversity of these perforated, partly perforated, or not perforated spheres or disks precluded the possibility of many of them having been intended for a usage of this kind, some were much too large, others too small or too thin. The mode of perforation, however, remains the same in a spheroid 4 or 5 inches thick as in an ostrich-shell discoidal bead. Instead of being merely perforated on one side, even the tiniest beads are bored on each side by means of minute rimmers (12 mm. long), which were exhibited. The larger boring tools or rimmers also exhibited could not, with perhaps the exception of one, have been really used for that purpose. Moreover, these perforated stones occur not only in South Africa, but also in Central Africa. He exhibited one that came from the Atacuma desert in Chile and which, but for the texture of the stone, which was lava from the Andes, might be alleged to come from any part of the Cape Colony. Absolutely similar stones were in use among the aborigines of some parts of New Guinea. These perforated stones, the mode of attachment of stone implements, the resemblance in Bushman and Australian mythology are point of resemblance between the aborigines of Africa and Polynesia which are not to be lightly passed over. He came to the conclusion that the manner in which these stones are pierced, and the rinders used, are derived from an unconscious tradition of the emblems of phallic worship. If this conclusion is a correct one, it might point towards the unity of the human family, and its dispersion from a common centre.

ORDINARY MONTHLY MEETING.

May 30, 1906.

Dr. J. C. **BEATTIE**, President, in the Chair.

Messrs. W. T. **SAXTON**, Dr. W. A. **HUMPHREY**, E. **JORISSEN**, and D. G. **SANDBERG** were elected Ordinary Members.

Dr. J. C. **Beattie** showed specimens of common glass coloured by sunshine.

Mr. L. **Péringuey** read a note "On Rock Etchings of Animals, &c.," the work of South African aborigines, and their relation to similar ones found in Northern Africa. He exhibited specimens of the etchings, and several photographs and impressions. These etchings are not uncommon along the Orange River, also the Vaal River, in the Asbestos Mountains, and other parts of the Colony, Beaufort West, Clanwilliam, Humansdorp, &c., also in the Transvaal, and he proceeded to compare these with etchings of a similar nature discovered and reproduced by the Geological Survey of Algeria. There the workmanship is of two kinds. The first kind is of very great antiquity, because among the representations are those, among others, of an extinct Buffalo of gigantic size, the nearest living ally of which is the Arni, or Indian Buffalo. This animal, known under the name of *Bubalus antiquus*, is probably identical with the one found in South Africa, and both may be the same as *Bubalus palæindicus*, of Falconer. Anyway, both are species found in the Pleistocene. As it is impossible to admit that an artist might have by pure chance depicted an animal which no longer existed at the time he figured it, we have to conclude that these artists were contemporaneous with the animal. The South African "rupestres" consist of picking instead of line drawings, and are thus somewhat similar to the second category of North African etchings, which represent non-extinct animals, and are thought to have been the work of a Lybico-Berber race. Barth, in his travels in the Soudan, recorded as far back as 1857 etchings on rocks, and they remind one of the mythical scenes of Bushman-paintings. Stowe divides the Bushmen into two groups, the sculptors and the painters, but it is quite possible that both the arts were known or practised at the same time and by the same people. The paintings would have decayed, the etchings remained well-nigh imperishable. We have no evidence of rock etchings being made of late times, but we have evidences of rock paintings having been made quite lately. The patina of some of these rock etchings could have been obtained through untold years only. Thus the race was very ancient indeed. It must be remembered also in connection with the etchings that we have evidence all over South Africa of a palæolithic age which cannot be attributed to the Bushmen, and which finds its exact counterpart in North Africa and also in the Congo region.

Dr. R. **Marloth** read a paper, "Observations on the Functions of the Ethereal Oils of Xerophytic Plants." Since the observations of Tyndall on the great diathermancy of the vapours of ethereal oils, many biologists think that the main function of these oils is to produce a protective atmosphere around the plants, thereby reducing their transpiration. If that were the case, one would expect that the excretion of oils should be largest in the driest season and the hottest part of the day. But just the reverse is the case, for many aromatic plants do not betray their presence at such times, while the atmosphere becomes filled with their aroma during foggy weather. Such plants are many Rutaceæ, Composites (wormwood), Umbelliferæ (Bubon), Palargonium, and even the Rhenosterbush. These facts are, however, in perfect accordance with the view that the oils are a protection against the attacks of herbivorous animals, especially also against snails and slugs, which appear only during wet weather.

ORDINARY MONTHLY MEETING.

Wednesday, June 27, 1906.

Dr. J. D. F. GILCHRIST in the Chair.

Miss A. V. DUTHIE was duly nominated as an Ordinary Member by R. BROOM and L. PÉRINGUEY.

Dr. J. D. F. GILCHRIST presented a paper on "Opisthobranchiata of South Africa," by Professor Berg, of Copenhagen, containing a description of forty new species, of which several represented new genera. The collection had been made by the Cape Government steamer and in-shore collecting. Both Tectibranchs and Nudibranchs were well represented. Among the former are eight new species of *Aptysia*. The general difference between the fauna of the East and West Coast was very marked in this group of marine animals, the region west of the Cape Peninsula having forms of northern character, though typically tropical forms of Nudibranchs are not wanting. The region to the east of the Cape of Good Hope has more of a tropical Indian character.

Dr. R. BROOM communicated five papers, four of which were taken as read:—

(1) "On the Early Development of the Appendicular Skeleton of the Ostrich, with Remarks on the Origin of Birds." It was shown that in the early embryo there are three well-developed toes and two others somewhat rudimentary. In the pelvis the pubis and ischium are directed downwards and united by

pro-cartilage. In the wing there are evidences of four digits. The author holds that birds are descended from bipedal reptiles somewhat intermediate in type between the Pterosaurs and the carnivorous Dinosaurs.

(2) "Note on the Lacertilian Shoulder Girdle." It is held that all the various cartilaginous and bony bars found in front of the shoulder girdle are merely parts of the true scapula and coracoid, and that there is no evidence of any precoracoid or epicoracoid elements, as is usually held. In the chameleon, which has no clavicle or collar-bone in the adult, a small clavicle is shown to be present in the embryo.

(3) "On some Little-known Bones in the Mammalian Skull." A considerable number of bones which are typically present in the reptilian skull, but which are not generally recognised as occurring among mammals, are shown to be occasionally present. The bones recognised are septomaxillary, prevomer, prefrontal, postfrontal, postorbital, and quadrate.

(4) "On a New Cynodont Reptile from the Molteno Beds of Aliwal North." A description is given of a new Cynodont, the first reptile that has been discovered in the Molteno beds.

(5) "On a New Rhynchocephalian Reptile from the Upper Beaufort Beds of South Africa." A description is given of a lower jaw of a small reptile allied to *Homœosaurus*. This is the oldest true Rhynchocephalian known.

"Notes on South African Cycads," by Professor H. H. W. **Pearson**, were read.

A number of field observations upon *Encephalartos Friderici-Guilielmi*, Lehm., *E. Villosus*, Lehm., *E. Altensteinii*, Lehm., and a species of *Stangeria* are recorded.

Evidence in support of the insect pollination of *E. Villosus* is adduced. It is pointed out that in *E. Friderici-Guilielmi* and *E. Altensteinii* the cones are laterally placed and the growth of the stem is therefore monopodial—not sympodial, as is usually stated. The importance of subterranean branching as a means of vegetative reproduction in *Stangeria* and in *E. Friderici-Guilielmi*, and its similarity to the type of vegetative reproduction which prevails in the Ferns, are discussed. The influence of external conditions, particularly of sunlight, upon the production of cones, is considered, and it is concluded that these conditions react on the Cycads in the same manner as on many of the higher flowering plants.

ANNUAL GENERAL MEETING.

August 9, 1906.

Dr. J. C. BEATTIE in the Chair.

The SECRETARY and the TREASURER read their Reports for the year 1905–1906.

REPORT OF SECRETARY.

Nine Ordinary Meetings and one General Meeting have been held during the year.

A lecture on the Zimbabwe Ruins was delivered by Mr. R. N. HALL, under the auspices of the Society.

Papers have been read:—

J. C. BEATTIE and J. LYLE, on "Atmospheric Electricity."

J. R. SUTTON, on "The Climate of East London."

E. HUTCHINS, on "The Cyclical Year, 1905, and the Coming Season."

A. L. DU TOIT, "Underground Water in South-Eastern Bechuanaland."

THOS. MUIR, "A set of Linear Equations connected with Homofocal Surfaces."

G. H. H. FINCHAM, on "The Nature of the Effect of the Sun-spot Frequency on the Variation of the Magnetic Elements of the Cape of Good Hope."

L. PÉRINGUEY, on "The Round Perforated Stones (Tikoe) alleged to have been made by Bushmen for the purpose of giving weight to the 'Kibi,' or Digging Stick."

L. PÉRINGUEY, on "Rock Engravings of Animals, &c., the Work of South African Aboriginals, and their relation to similar ones found in Northern Africa."

R. MARLOTH, "Observations on the Functions of the Ethereal Oils of Zerophytic Plants."

R. BERG, "Opisthobranchiata" of South Africa.

R. BROOM, on "The Early Development of the Appendicular Skeleton of the Ostrich, wtih remarks on the Origin of Birds."

R. BROOM, "Note on the Lacertilian Shoulder Girdle."

R. BROOM, on "Some Little-known Bones in the Mammalian Skull."

R. BROOM, on "A New Cynodont Reptile from the Molteno Beds of Aliwal North."

R. BROOM, "On a New Rhynchocephalian Reptile from the Upper Beaufort Beds of South Africa."

TREASURER'S STATEMENT.

THE TREASURER IN ACCOUNT WITH THE SOUTH AFRICAN PHILOSOPHICAL SOCIETY.

RECEIPTS.	£	s.	d.
To Balance in Bank, on fixed deposit at 3 per cent. ..	100	0	0
,, Floating Balance in Bank as per Pass Book	72	4	6
,, Paid into floating deposit out of fixed deposit	75	0	0
,, Interest on deposit	6	1	6
,, Petty Cash Balance	2	18	6
,, Sale of Transactions	76	15	1
,, Subscriptions	302	4	6
	£635	4	1

EXPENDITURE.	£	s.	d.	£	s.	d.
By Publications	229	7	6			
,, Local Printing	25	5	6			
,, Freight, Insurance, Landing Charges ..	12	3	3			
,, Library Rent, Book Shelves	38	17	5			
,, Stationery and Binding	5	8	0			
,, Stamps and Petties	45	0	0			
,, Hire of Hall and Lantern	4	4	0			
,, Compilation of Scientific Catalogue ..	10	0	0			
,, Attendant and Clerical help	12	10	0			
,, Bank Exchange	0	18	2			
				383	13	10
,, Balance in Bank on fixed deposit	100	0	0			
,, Floating Balance in Bank, as per Pass Book	151	10	3			
				251	10	3
				£635	4	1

We, the undersigned members of the South African Philosophical Society, hereby declare that we have examined the above account, compared Receipts with the Counterfoils of the Receipt Book, the Cash Payments with the Vouchers and the Balance with the Bank Pass Book, and have found the same correct.

(Signed) ARTHUR W. ROGERS, } *Auditors.*
ALEX. L. DU TOIT, }

T. **Muir**, "The Expression of Certain Symmetric Functions as an Aggregate of Fractions."

H. H. W. **Pearson**, "Notes on South African Cycads."

P. **Cameron** (*a*), Description of some New Species of Hymenoptera; (*b*), on "Hymenopterous Parasites of the Mealie Stalk Borer, *Sesamia fusca;* (*c*), on "Two Species of Ichneumonidæ Parasites of the Codling Moth in Cape Colony."

L. **Péringuey**, "Descriptive Catalogue of the South African Coleoptera (Cetonidæ).

L. **Péringuey**, "The Stone Implements of South Africa."

Two of these papers are still in the hands of the Secretary so as not to unduly inflate the printing account of the year. The others are being printed, or are by this time in the hands of the printers.

During the year the Society has issued parts 5 of Vol. XV.; parts 1 and 2 of Vol. XVI., making 411 pages and 3 plates; part 3 of the same volume is shortly expected.

Sixteen members have resigned their membership; 2 have left no address; 10 have been removed from the list owing to long arrears in the payment of their yearly subscriptions; we have lost 1 by death. Against this reduction of 26 names, 13 new members have been elected during the year, and the Members' Roll now consists of 214 names.

From the Treasurer's Report it will be seen that mainly owing to the large amount received from the sale of publications (£76 12s. 2d.), the receipts of the year (£378 16s. 8d.) cover the expenditure (£382 14s. 8d.), but the printing account for the incoming year will prove to be a very heavy one.

Dr. J. C. **Beattie** was elected President for the year 1906–1907.

Professor L. **Crawford**, Rev. Dr. W. **Flint**, S. S. **Hough**, Dr. R. **Marloth**, and A. W. **Rogers** were elected members of the Council for two years.

Dr. J. C. **Beattie** read his Presidential Address on "Physical Problems in South Africa."

The Annual Meeting resolved itself into an Ordinary Meeting.

Miss A. V. **Duthie**, of Stellenbosch, was elected an Ordinary Member of the Society.

Mr. C. W. **Howard**, of Pretoria, was nominated an Ordinary Member by M. Wilman and L. Péringuey.

The **President** gave notice that at a Special Meeting to be held for the purpose a proposal will be made to alter the Rules of the Society when the latter receives its Charter.

LIST OF MEMBERS,

For year ending June 30, 1906.

MEMBERS OF COUNCIL.

Beattie, J. C., *President.*
Crawford, L.
Flint, Wm.
Gilchrist, J. D. F.
Gill, Sir David.
Marloth, R.
Morrison, J. T.
Pearson, H. H. W.
Péringuey, L., *Secretary.*
Lounsbury, C. P.
Sclater, W. L.

HONORARY MEMBERS.

1897 Fisk, *Rev.* G. H. R., *C.M.Z.S.*, Church House, Cape Town.
1897 Trimen, R., *F.R.S.*, Ovingdean, Surbiton, Surrey.
1900 Seeley, *Prof.* H. G., *F.R.S.*, King's College, London.
1905 Lord Milner, Brooke's Club, London.
1905 A. Raffray, 6, Piaza Madama, Rome.

ORDINARY MEMBERS.

1897 Alston, E. G., Roodepoort, O. R. C.
1901 Alston, J. A., *M.R.C.S.*, Union Street, Cape Town.
1890 Amphlett, G. T., Standard Bank, Cape Town.
1901 Anderson, A. J., *M.A.*, *M.B.*, Medical Officer of Health, Cape Town.
1886 Anderson, T. J., *M.L.A.*, Cape Town.
1900 Anderson, Wm., Great King Street, Edinburgh.
1877 Arderne, H. M., The Hill, Claremont, C. C.
1904 Arderne, H. R., Arderne's Buildings, Cape Town.
1905 Backhouse, J. S., *B.A.*, Public Works Department, Cape Town.
1897 Barker, C. N., Rownham, Malvern, Natal.
1901 Baxter, W., *M.A.*, South African College School, Cape Town.
1899 Beard, Herbert R., *B.A.*, Woodside, Wynberg, C. C.
1897 Beattie, J. C., *D.Sc.*, *F.R.S.E.*, South African College, Cape Town.
1882 Beck, J. H. M., *M.D.*, Tulbagh, C.C.
1904 Becker, H., *M.D.*, *F.L.S.*, Graham's Town, C. C.
1901 Benjamin, L. E., *B.A.*, *LL.B.*, Cape Town.
1899 Berry, *Hon. Sir* Wm. Bisset, *M.D.*, Houses of Parliament, Cape Town.
1894 Besté, *Rev.* W., Stutterheim, C. C.
1905 Bodong, A., Beira.
1877 Bolus, H., *D.Sc.*, *F.L.S.*, Kenilworth, C. C.

1897 Brauns, J. H., *M.D.*, *Ph.D.*, Willowmore, C. C.

1903 Brink, A., P.O. Box, 616, Kimberley.

1900 Broom, R., *M.D.*, *B.Sc.*, Victoria College, Stellenbosch, C. C.

1904 Brown, A., *M.A.*, South African College, Cape Town.

1904 Brown, W. H., Cradock.

1877 Buchanan, *Hon. Sir* John, Claremont, C. C.

1905 Burt-Davy, J., *F.L.S.*, Agricultural Department, Johannesburg.

1905 Caink, F. G., Town House, King William's Town.

1906 Caldecott, W. A., *B.A.*, Box 1167, Johannesburg.

1903 Caley, R., Fort Beaufort, C. C.

1902 Campbell, S. G., *M.D.*, Durban, Natal.

1905 Cornish-Bowden, A. H., Surveyor-General's Office, Cape Town.

1898 Churchill, F. O. F., Ennersdale, Natal.

1899 Clark, G. M., *M.A.*, *A.M.I.C.E.*, Reitfontein, Klerksdorp, Transvaal.

1901 Colson, R., Lydenburg, Transvaal.

1896 Cooper, A. W., Richmond, Natal.

1895 Corstorphine, G. S., *B.Sc.*, *Ph.D.*, P.O. Box 1,167, Johannesburg.

1896 Cowper, Sydney, *C.M.G.*, Cape Town.

1901 Cox, J. H., *M.R.C.S.*, Cape Town.

1901 Craig, William, *A.M.I.C.E.*, Public Works Dept., Cape Town.

1899 Crawford, Lawrence, *M.A.*, *D.Sc.*, South African College, Cape Town.

1895 Cregoe, J. P., P.O. Box 1,420, Johannesburg.

1905 Denham, J., Railway Department, Cape Town.

1905 Dewar, W. R., Agricultural Department, Graham's Town.

1902 Dinter, Kurt, Windhoek, German S.W. Africa.

1890 Dodds, W. J., *M.D.*, Valkenburg, Mowbray, C. C.

1902 Dodt, J., Museum, Bloemfontein, O. R. C.

1898 Drege, J. L., Port Elizabeth, C. C.

1901 Dwyer, F. L., C.G.R., Cape Town.

1903 Dyer, B., Library, Kimberley, C. C.

1877 Ebden, *Hon.* A., Rondebosch, C. C.

1895 Evans, M. S., *F.Z.S.*, Durban, Natal.

1890 Fairbridge, W. G., 133, Longmarket Street, Cape Town.

1899 Feltham, H. L. L., P.O. Box 46, Johannesburg.

1900 Findlay, F. N. R., Rustenburg, Transvaal.

1892 Fletcher, W., Ratel River, Caledon, C. C.

1901 Flint, *Rev.* Wm., *D.D.*, Rosebank, C. C.

1905 Ffolliott Darling, Jos., *F.Z.S.*, Salisbury.

1901 Fourcade, H. G., Storms River, Knysna, C. C.

1903 France, E., *M.B.*, South African Association Building, Cape Town.

1898 Fry, Harold A., P.O. Box 46, Johannesburg.

1899 Fuller, C., *F.E.S.*, Agricultural Dept., Maritzburg.

1895 Fuller, E. Barnard, *M.B.*, Church Square, Cape Town.

1904 Galpin, E. E., *F.L.S.*, Queenstown, C. C.

1896 Gilchrist, J. D. F., *M.A.*, *B.Sc.*, *Ph.D.*, South African Museum, Cape Town.

1879 Gill, *Sir* David, *K.C.B.*, *LL.D.*, *F.R.S.*, Royal Observatory, Cape Town.

1904 Goetz, *Rev.* E., *S.J.*, The Observatory, Bulawayo.

1897 Graham, F. G. C., Graham's Town, C. C.

1901 Grant-Dalton, A., *M.I.C.E.*, Cape Govt. Railways, Cape Town.

1899 Gray, Charles J., Department of Mines, Maritzburg.

1904 Haarhoff, D. J., *M.L.A.*, Kimberley.

1905 Harger, H. S., P.O. Box 1,945, Johannesburg.

1905 Hall, O. L., *B.A.*, *F.G.S.*, Geolog. Survey, Pretoria.

1902 Havers, P., Stellenbosch, C. C.

1902 Hayward, S. H., Hofmeyr Chambers, Cape Town.

1901 Hely-Hutchinson, *H.E.*, The *Hon. Sir* W. F., *G.C.M.G.*, Government House, Cape Town.

1902 Herbert, H. A., African Banking Corporation, Cape Town.
1901 Hewat, M. L., *M.D.*, Steyning, Mowbray, C. C.
1902 Hoop, van der, A. C., Consul-General for the Netherlands, Cape Town.
1899 Hough, S. S., *M.A.*, *F.R.S.*, Royal Observatory, C. C.
1889 Howard, R. N., *M.R.C.S.*, O'okiep, C. C.
1896 Hugo, *Hon.* J. D., Worcester, C. C.
1891 Hutcheon, D., *M.R.C.V.S.*, Dept. Agriculture, Cape Town.
1897 Hutchins, D. E., *F.R.M.S.*, Kenilworth, C. C.
1903 Innes, R. T. A., Meteorological Dept., Johannesburg.
1905 Jagger, J. W., *F.R.S.S.*, *M.L.A.*, St. George's Street, Cape Town.
1883 Janisch, N., Colonial Office, Cape Town.
1903 Johnson, J. P., Roodepoort, Transvaal.
1906 Jorissen, E., Box 305, Johannesburg.
1898 Juritz, C. F., *M.A.*, Government Laboratory, Cape Town.
1905 Keytel, P. C., Brighton Castle, Beach Road, Cape Town.
1902 Kilpin, E. F., *C.M.G.*, Houses of Parliament, Cape Town.
1902 Kipling, Rudyard, Rottingdean, Brighton, England.
1896 Kitching, C. McGowan, *M.D.*, Church Street, Cape Town.
1896 Kolbe, *Rev.* F. C., *B.A.*, *D.D.*, St. Mary's Presbytery, Cape Town.
1900 Krapohl, J. H. C., *B.A.*, Concordia, C. C.
1905 Kynaston, H., Geolog. Survey, Pretoria.
1903 Ladds, J. G. McLear, Cape Govt. Railways, Cape Town.
1903 Landsberg, E., *M.B.*, Cape Town.
1900 Lawn, *Prof.* J. G., P.O. Box 231, Johannesburg.
1905 Lawrence, F. J., Steytlerville, C. C.
1901 Leslie, T. N., Vereeniging, Transvaal.
1902 Lewis, A. J., Government Laboratory, Cape Town.
1904 Lewis, F. C., South African Library, Cape Town.
1888 Lindley, J. B., *C.M.G.*, *M.A.*, Claremont, C. C.
1892 Lithman, K. V., Dock Road, Cape Town.
1901 Logeman, W. S., South African College, Cape Town.
1905 Long, E. C., *M.R.C.S.*, Maseru, Basutoland.
1895 Lounsbury, C. P., *B.Sc.*, Department of Agriculture, Cape Town.
1905 Loveday, T., South African College, Cape Town.
1901 Lyle, J., *M.A.*, Grey College, Bloemfontein, O. R. C.
1902 Maberly, J., *M.R.C.S.*, Woodstock, C.C.
1899 McEwen, T. S., *A.M.I.C.E.*, General Manager Cape Govt. Railways, Cape Town.
1905 Macco, A., Stassfurt, Germany.
1903 MacDonald, G. B. Douglass, Uniondale, C. C.
1905 MacLean, L., Union-Castle Co., Cape Town.
1900 Macmillan, B. R., Department of Agriculture, Cape Town.
1902 Mallison, P. R., Hex River, C. C.
1900 Mally, C. W., *B.Sc.*, Garrison, Texas.
1894 Mally, L., Belvedere Avenue, Cape Town.
1903 Mann, G., South African Association, Cape Town.
1898 Mansergh, C. L. W., Public Works Department, Cape Town.
1885 Marloth, R., *Ph.D.*, *M.A.*, Church Street, Cape Town.
1897 Marshall, G. A. K., *F.E.S.*, *F.Z.S.*, P.O. Box 56, Salisbury, Southern Rhodesia.
1900 Masey, F. E., Rhodes' Buildings, Cape Town.
1899 Masson, J. L., Surveyor-General's Office, Maritzburg.
1901 Meacham, C. S., Mariedahl, Newlands, C. C.
1897 Meiring, I. P. van H., Worcester, C. C.
1906 Mellor, E. T., *B.Sc.*, *F.G.S.*, Geolog. Survey, Pretoria.
1901 Melvill, E. H. V., Johannesburg.

1903 Menmuir, R. W., *A.M.I.C.E.*, Woodstock, C. C.
1902 Mennell, F. P., Rhodesian Museum, Bulawayo.
1899 Millar, A. D., Durban, Natal.
1903 Milligan, A., D'Urban.
1899 Moffat, J. B., Kenilworth, C. C.
1898 Molengraff, G. A. F., *Ph.D.*, P.O. Box 149, Johannesburg.
1905 Morris, F. M., *M.B.*, Hope Street, Cape Town.
1896 Morrison, J. T., *M.A.*, *B.Sc.*, *F.R.S.E.*, Victoria College, Stellenbosch, C. C.
1892 Muir, T., *C.M.G.*, *LL.D.*, *F.R.S.*. Department of Education, Cape Town.
1902 Muirhead, J. M. P., *F.S.S.*, Selwyn Chambers, St. George's Street, Cape Town.
1903 Muller, H. J., Willowmore, C.C.
1903 Nobbs, E., *Ph.D.*, Department of Agriculture, Cape Town.
1901 Noorden, P. M. van, Willowmore, C. C.
1899 Oakley, H. M., The Colonnade, Greenmarket Square, Cape Town.
1901 Ohlsson, O. A., 10, Adderley Street, Cape Town.
1904 O'Meara, E. A., *D.S.O.*, P.O. Box 3,243, Johannesburg.
1902 O'Neill, *Rev.* J. A., *S.J.*, Dunbrody, Uitenhage, C. C.
1904 Oppenheimer, E., P.O. Box 273, Kimberley.
1900 Orpen, J. M., Bulawayo.
1903 Payne, H., *A.M.I.C.E.*, South African College, Cape Town.
1903 Pearson, H. H. W., *M.A.*, *F.L.S.*, South African College, Cape Town.
1895 Péringuey, L., *D.Sc.*, *F.E.S.*, *F.Z.S.*, South African Museum, Cape Town.
1905 Pickering, F., *M.I.E.E.*, Railway Dept., Cape Town.
1902 Pickstone, H. E. V., Groot Drakenstein, Paarl.
1904 Pollitt, R. B., *A.M.I.C.E.*, Johannesburg.
1905 Potts, G., *B.Sc.*, *Ph.D.*, Bloemfontein.
1901 Proctor, J., George, C. C.
1895 Purcell, W. F., *Ph.D.*, *M.A.*, South African Museum, Cape Town.
1899 Queckett, J. F., *F.Z.S.*, The Museum, Durban, Natal.
1901 Reunert, T., *M.I.C.E.*, P.O. Box 92, Johannesburg
1896 van der Riet, B., *Ph.D.*, *M.A.*, Victoria College, Stellenbosch, C. C.
1900 Ritchie, W., *M.A.*, South African College, Cape Town.
1902 Ritso, B. W., *F.G.S.*, Public Works Department, Cape Town.
1898 Rix Trott, H., Poste Restante, New Zealand.
1900 Robertson, G. W., *M.R.C.S.*, Department of Agriculture, Cape Town.
1896 Rogers, A. W., *M.A.*, *F.G.S.*, South African Museum, Cape Town.
1897 Ross, A., *F.Z.S.*, P.O. Box 1,461, Johannesburg.
1900 Russell, W. A., *M.A.*, Education Office, Cape Town.
1890 Ryan, P., Rosebank, C. C.
1906 Sandberg, Jonkheer C.G.S., *D.Sc.*, Box 305, Johannesburg.
1906 Saxton, W. T., *B.A.*, South African College, Cape Town.
1890 Schönland, S., *Ph.D.*, *M.A.*, Albany Museum, Graham's Town, C. C.
1896 Schreiner, *Hon.* W. P., *C.M.G.*, *M.A.*, *K.C.*, Lyndale, Newlands, C. C.
1878 Schunke-Hollway, H. C., *F.R.G.S.*, Simondium, Paarl, C. C.
1895 Schwarz, E. H. L., *A.R.C.S.*, *F.G.S.*, Albany Museum, Graham's Town.
1896 Sclater, W. L., *M.A.*, *F.Z.S.*, South African Museum, Cape Town.
1905 Shepperd, P. A., Beira.
1901 Shepperd, H. P., Stellenbosch, C. C.
1877 Silberbauer, C. F., Rondebosch, C. C.
1877 Smith, the *Hon. Sir* C. Abercrombie, *M.A.*, Wynberg, C. C.
1902 Smith, *Hon.* G. D., Cape Town.
1900 Stanford, W. E. M., *C.B.*, *C.M.G.*, Native Affairs Office, Cape Town.

1904 Stebbins (Miss), I. F., *B.A.*, Huguenot Seminary, Wellington.
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